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ADDITIONAL GARDEN CITY (EARLY ORDOVICIAN) TRILOBITES

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ABSTRACT—Continued study on the silicified trilobites of the Garden City formation of Utah has resulted in the discovery and description of the new genus *Psalikilopsis* and of the new species *P. cuspidicauda* Ross, *Scinocephalus quadrihastatus* Ross, *Menoparia lunalata* Ross, *Pseudohystricurus orbus* Ross, and *Licnocephala ovata* Ross. The derivation of *Menoparia* from *Apatokephalus* is suggested by the change in its dorsal furrows throughout its stratigraphic range, and problematical meraspid pygidia are described for the genotype. The presence of a peculiar rostral structure in *Dimeropygiella* is established. Bathyurid affinities of *Licnocephala* are suggested by the presence of a rostral plate and elongate, dorsally directed appendifers on the hypostome; the concept of this genus is broadened to include three species showing considerable variation in cranidial features.

INTRODUCTION

SINCE publication of earlier investigations on the trilobites of the Garden City formation of Utah (Ross, 1951a and 1951b) study has continued to require revision of some of the original generic and specific descriptions, has resulted in the discovery of several new species and genera, and has extended the known stratigraphic ranges of others. One new genus and five new species are presented here, all from the prolific "G" zone of the formation.

Collections on which the present paper is based were secured with financial assistance from the Marsh Fund of the National Academy of Science in 1949 and from the Research Committee of Wesleyan University. Field assistants were James A. Parkinson and C. Gilbert Bowles. Preparation of some of the studied material was done by R. P. Briggs and D. T. Sanders. Dr. Lehi F. Hintze very kindly furnished manuscript proof copies of plates accompanying his paper on Lower Ordovician trilobites secured from the Garden City or equivalent formations in southern and western Utah. He, Dr. H. B. Whittington, and Dr. W. R. Evitt have graciously supplied comments and/or unpublished information relevant to the interpretation of several of the species through frequent personal communication.

Terminology.—The terminology used in the descriptions which follow is essentially that of Howell et al. (1947), as modified by Ross (1948). The terms "sagittal" (sag.), "ex-sagittal" (ex-sag.), and "transverse" (tr.) are used following Richter (1940, pp. 16–17), Whittington (1950, p. 533), and Evitt (1951, p. 587).

SYSTEMATIC DESCRIPTIONS

Genus MENOPARIA Ross, 1951

At the time of its original description it was not possible to draw any conclusions as to the type of hypostome possessed by this

genus. At present there is still no definite assignment, but some inference can be drawn from association throughout the entire stratigraphic range of the genus in the Garden City beds.

There appear to be two types of hypostomes which are associated with specimens of *Menoparia* in almost all samples examined; these are illustrated in Plate 62, figures 14 and 18. The second of these is very similar to the hypostome assigned by Hintze (1952) to a species of *Megalaspidiella*, which also occurs in the Garden City fauna. That illustrated in Plate 62, figure 14, is considered the more likely candidate for assignment to *Menoparia genalunata* Ross and is described below.

It was this author's previous belief that a single species of *Menoparia* ranged throughout the "G" zone (1951a, p. 28). The new species, *M. lunalata*, described below, occurs higher but still within this zone. On the other hand specimens of the genotype occur at the very base of the "G" zone in which the characteristic crescent of the fixed cheek is so narrow as to appear gradational between that species and a new species here assigned tentatively to *Apatokephalus*. No distinction has yet been made between the free cheeks or pygidia of any of these species.

MENOPARIA GENALUNATA Ross
Plate 62, figures 3, 4, 6, 7, 9–11, 13–17, 19–20

Menoparia genalunata Ross, 1951a, Peabody Mus. Nat. Hist. (Yale), Bull. 6, pp. 88–89, pl. 20, figs. 13–24, 28, 29, 34–35; Ross, 1951b, Jour. Paleontology, vol. 25, pp. 579–583, pl. 81, figs. 1–14, 18–19; pl. 83, figs. 19–21.

In calling attention to the ontogenetic development of this species from a subovoid protaspid (Ross, 1951b, pp. 479–583) uncertainty was expressed concerning the correct interpretation of the structure of the posterior portion of the protaspid and of the meraspid stages of the pygidium. Continued observations of the immature fractions of the fauna may throw additional, if indefinite, light on this question.

Associated with these protaspids and with the "horned" meraspid cranidia (plate 62, fig. 6) there are invariably three kinds of pygidia. The first of these are adult or immature but very similar to those of adult proportions (plate 62, figs. 15, 19); the smallest of this category are about 0.6 mm. in axial length and twice as wide. The second type, the smallest, possess a very long posterodorsally directed axial spine (plate 62, fig. 20; Ross, 1951b, plate 83, fig. 19); the axial length, exclusive of the spine, is close to 0.3 mm. The apparent difference between these two types is easily reconciled when one considers that the segment bearing the axial spine almost certainly migrates forward through the pygidium into the thorax with successive moults (Ross, 1951b, p. 586). In other respects the two pygidia are very similar indeed, but the steps leading from what seems to be the protopygidium of the protaspid (Ross, 1951b, pp. 580–581) to the small spined pygidium are very difficult to visualize.

The third associated pygidial type may fill the gap. These pygidia are semi-elliptical in outline (plate 62, figs. 7, 10) with a strongly developed, semicylindrical, slightly tapering axis of five rings and a strong, erect terminal boss (plate 62, figs. 13, 16). In lateral view the pleural platforms curve evenly downward and backward, comparing favorably with the posterior portion of the protaspid (Ross, 1951b, plate 81, figs. 4–9). On a slight diagonal faint interpleural furrows cross the pleural platforms (plate 62, fig. 10) and with incipient spines along the margin indicate the position of five pairs of pleura. The pygidia are generally 0.6 mm. in length. They are compatible in size with separate meraspid cranidia (plate 62, fig. 6) and may therefore be meraspid pygidia.

It is conceivable that the five pleural segments developed at this stage later become the first five segments of the thorax and that none of the digitate pleura of the more mature pygidia are yet developed. One may speculate further that the small medially spined pygidia are formed by the addition of segments at the rear and that the terminal boss is prolonged into the long, semierect axial spine of the second (?) stage. If this speculation is correct one might expect to find the sixth thoracic segment of the holaspid bearing a spine; that some associated thoracic segments assignable to this species do bear such spines is a fact.

The above is submitted here as speculation which meets with several obstacles. The first of these is the lack of a continuous series

of growth stages to verify or disprove it. The second is uncertainty as to whether the third pygidial type (plate 62, figs. 7, 10) belongs to this species, or even to the genus. There is at least one asaphid-type genus to which it may be assignable, especially as its more mature specimens show similar development of the pygidial axis. The resemblance of these pygidia to the "protopygidial" portion of the subovoid protaspids cannot be denied, but even this runs into difficulties; there are two distinct types of subovoid protaspids in the "G" and higher zones of the formation. This second type, as yet undescribed, is characterized by the possession of a peculiar process shaped much like a "handle-bar" moustache projecting from the posteroventral margin of the carapace in an anterior direction. It always occurs associated with asaphid-type adults, its stratigraphic range extending above that of *Menoparia;* neither the first type of subovoid protaspids nor the "protopygidia" in question have been found outside *Menoparia's* range, however.

Cranidium.—The holotype and most of the original paratype material of this species were taken from the "G(2)a–c" zones (lower half of the *Protopliomerops contractus* zone of Hintze (1952), there being few well-preserved specimens from the original collections from zone "G(1)" (*P. celsaora* zone of Hintze). Better material secured in 1949 from the lower zone shows that the transverse width of the crescentic fixed cheeks is far less than in the higher material, as shown by a comparison of Plate 62, figures 3 and 4 with Ross, 1951a, Plate 20, figures 14 and 28. The importance of this difference is emphasized by the occurrence in the lower subzone of numerous cranidia lacking any crescentic fixed cheek and tentatively assigned to *Apatokephalus*, below.

Hypostome.—(plate 62, fig. 14) The hypostome tentatively assigned to this species is roughly quadrate in outline. The anterior wings are set off from the middle body by a well-defined furrow, and are flexed in a posterodorsal direction, being narrowly triangular. The convex middle body is broadly elliptical, surrounded by a pronounced furrow, and divided transversely by the faintest suggestion of a constriction (not a furrow) in front of the maculae. The maculae are low and transversely elliptical; there is no pit in front of them. The lateral rim is thick and modified to form a pair of posterolateral points. Posteriorly there is a broad, gently rounded, median thickening of the rim, while a pair of faint nubs lie between the median thickening and the posterolateral points.

If the assignment of hypostome is correct it meets with another difficulty, for the curve of the posterior edge of the cephalic doublure on the free cheek is unbroken (plate 62, fig. 17). The leading edges of the anterior wings, however, indicate that the hypostomal suture can be divided roughly into three segments. Since the free cheeks clearly join along a median suture it is possible that a rostrum may have been present between them and the hypostome to the rear.

Figured specimens.—YPM Nos. 18754, 18756–18763, 18765.

Occurrence.—All specimens figured here with the exception of the hypostome were collected from the base of the "G" zone at locality 6, Garden City formation (Ross, 1951a, p. 16). Based on 1946 computations this would be a little less than 480 feet stratigraphically above the base of the formation; based on 1949 measurement this spot is computed as being 580 feet above the base. In both cases the slope distance southward along the crest of the ridge from the base of the formation is 2,140 feet. The hypostome illustrated was taken from the middle of the "G" zone, a slope distance of 2,537 feet south of the base of the formation, computed to 670 stratigraphic feet above the base.

MENOPARIA LUNALATA Ross, n. sp.
Plate 62, figures 22–24

Description.—Cranidium essentially like *M. genalunata* Ross but with wider (transversely) crescentic fixed cheeks, less convex (almost flat) glabella between the palpebral lobes, narrower (exsag.) lateral extensions of the "hammer-headed" frontal portion, and with the anterior one of the two obvious pairs of glabellar furrows located further inside the curving dorsal (axial) furrows. Eight or nine pairs of pits in the anterior marginal furrow.

It has not yet been possible to ascertain

any significant difference between the thoracic segments and pygidium of this species and those of *M. genalunata*.

Holotype.—YPM No. 18766.

Discussion.—Differences between the two species cannot be attributed to stage of growth, for ample material is now available to permit comparisons over a much greater size range of *M. genalunata* than was previously possible. A useful ratio which is not immediately obvious in distinguishing between the two species is secured by dividing the over-all midlength of the cranidium by the transverse width at the "hammer-headed" frontal extension; in *M. lunalata* this ratio equals approximately 0.75, while in the genotype it is 0.9 or slightly higher.

The occurrence of this species near the top of the "G" zone and above the normal range of the genotype is of special interest in connection with representatives of the latter discovered at the base of the zone (see above). If attention is centered on the crescentic fixed cheeks it is noted that they are exceedingly narrow at the base of the "G" zone (plate 62, figs. 3–4), that they widen in younger specimens (Ross, 1951a, plate 20, figs. 14, 28; 1951b, plate 83, fig. 20), and reach their maximum known width in *M. lunalata* (plate 62, fig. 23). To this must be added the fact that another species, tentatively referred to *Apatokephalus*, is also present at the base of the zone (plate 62, fig. 12), in which no crescentic fixed cheeks are developed at all. Finally, we may note that Hintze (1952) has reported the occurrence of *Apatokephalus finalis* Walcott (*Diplapatokephalus finalis* of Raymond) in his *Leiostegium-Kainella* zone (approximate "D" zone of this author (1951a)) in the Pogonip formation, Ninemile Canyon, Antelope Range, Nevada.

From the above it appears that *Menoparia* may be a descendant from *Apatokephalus*, and that in successive evolutionary stages the distinctive crescentic fixed cheek increases in width, following the loss of the anterior pair of glabellar furrows. Throughout the series there is no apparently significant change in the proportions of the glabella, although the ontogeny of *M. genalunata* (Ross, 1951b, pp. 581–582, plate 81, figs. 12, 14, 18) and equally small specimens associated with both *M. lunalata* and the new *Apatokephalus* species suggest derivation from some form with a parallel-sided glabella, such as *Richardsonella*, *Kainella*, or *Pseudokainella*.

Occurrence.—Locality 6, 770 feet above the base of the Garden City formation (Ross 1951a, pp. 16–17); slope distance southward along crest of ridge from base of the formation equals 2,960 feet. Corresponds to high "G" zone of this author, or high *Protopliomerops contracta* zone of Hintze (1952).

Genus APATOKEPHALUS Brögger, 1897

APATOKEPHALUS ? sp.

Plate 62, figures 8, 12

Description.—Cranidium essentially the same as that of *Menoparia genalunata* Ross except that dorsal and palpebral furrows are not separate. Hence there is no crescentic fixed cheek. Only two pairs of glabellar furrows are present. No distinction is apparent between free cheeks and pygidia which can be assigned to this species and to associated specimens of *M. genalunata*.

Figured specimen.—YPM No. 18767.

Discussion.—Of the related genera this species is closest to those of *Apatokephalus*, but differs in the lack of the anterior or "first" pair of glabellar furrows, as do the species of *Menoparia*. Its assignment is therefore open to question. Unfortunately the only complete cranidia are smaller than that figured and are obviously immature. Four fragmentary specimens of much larger individuals show conclusively that the lack of crescentic fixed cheek cannot be related to stage in ontogeny. They also show that pits are present in the anterior marginal furrow, but the exact number cannot be determined.

Until additional specimens are available of a nature suitable for specific designation and description the main importance of this species lies in its stratigraphic relation to *M. genalunata*, *M. lunalata* n. sp., and *A. finalis* Walcott, discussed above. The association with specimens of *M. genalunata*, all of which have very narrow fixed cheeks, suggests that a very unstable population existed and that we may here be dealing with the first forms of *Menoparia* derived from an *Apatokephalus* or *Apatokephalus*-like stock.

Attempts to differentiate two distinct

types of free cheeks and pygidia have met with no success. It is entirely possible that specimens illustrated in Plate 62, figures 15, 17, 19, belong to this species, rather than to the forms of *M. genalunata* with narrow fixed cheeks.

Occurrence.—Base of the "G" zone, locality 6, Garden City formation (Ross, 1951a, p. 16), 580 feet stratigraphically above the base of the formation; located at a slope distance of 2,140 feet southward along the crest of the ridge from the base of the formation.

Genus SCINOCEPHALUS Ross, 1951

SCINOCEPHALUS ? QUADRIHASTATUS Ross, n. sp.

Plate 62, figures 21, 25

Description.—Cranidium, free cheeks, and thoracic segments of this species are not known with certainty. The pygidium resembles that of *S. solitecti* except for the fact that it bears only two pairs of dagger-shaped pleural spines in addition to the single tiny median spine. The dorsal side of the pleural area has the same degree of concavity as the genotype and the axis is of the same very short, strongly convex type (plate 62, fig. 21). Individual pleura are considerably wider, however.

Holotype.—YPM No. 18768.

Discussion.—This species is represented by six small pygidia in the present collection. Associated with these are specimens of cranidia, free cheeks, and pygidia of *Menoparia genalunata* as well as several free cheeks and cranidia which appear to be identical with those of *S. solitecti*. There are no pygidia present in the association of the type belonging to the latter species. These associations plus the fact that the sample was taken approximately five feet stratigraphically above the highest substantiated occurrence of *S. solitecti* suggest that the subject pygidia do belong to the genus *Scinocephalus* and that the number of pygidial segments may not be generically important in this case. Of similar or related genera only *Remopleurides* possesses as few as two pairs of spines on the pygidium.

In the original descriptions of the genotypes of *Menoparia* and *Scinocephalus* this author made only brief mention of a feature of the pygidia of which there is increasing evidence for generic significance (Ross, 1951a, p. 89). In *Menoparia* there is invariably a minute median pair of pleural spines regardless of stage in ontogeny. In *Scinocephalus* there is only a single minute median spine, as shown by all growth stages examined of the genotype. The species described here conforms to the latter case (plate 62, fig. 25).

Occurrence.—Zone "G," Locality 6, Garden City formation (Ross, 1951a, pp. 16–17, 27). Appears to coincide with base of *Protopliomerops contracta* zone of Hintze (1952). Based on 1949 remeasuring of section 713 feet stratigraphically above the base of the formation; located at a slope distance of 2,633 feet southward along crest of ridge from base of formation.

Genus DIMEROPYGIELLA Ross, 1951

DIMEROPYGIELLA CAUDANODOSA Ross

Plate 63, figures 24, 25, 28–30; text figure 1

Dimeropygiella caudanodosa Ross, 1951a, Peabody Mus. Nat. Hist. (Yale), Bull. 6, pp. 124–125, pl. 35, figs. 18, 22–28.

Dimeropygiella caudanodosa Ross, HINTZE, 1952, Utah Geol. Min. Survey, Bull. 48, pl. 19, figs. 5, 10.

Description.—The original description of this species must be altered to some extent as regards the free cheeks and facial sutures. Although immature, the specimen illustrated in Plate 63, figures 24, 28–30 appears to indicate that the right and left free cheeks are solidly yoked across the front of the cephalon and that the yoking portion is equipped with an enormous conical ventrally directed spine. This belief was held until very recently and was the basis for remarks made by Whittington and Evitt (MS) in their revision of the family Dimeropygidae.

In cleaning this specimen preparatory to placing it in storage it was noted that a perfectly clean-cut suture could be made out when the specimen was soaking in acetone; its position is illustrated in text figure 1. Therefore, *Dimeropygiella* joins *Dimeropyge* and *Törnquistia* in the possession of a rostral plate between the cheeks, although its ventral spine is unique.

In the Garden City genus notch-like Panderian openings are present, one pair being located immediately anterior to the base of the genal spine as notches in the

edge of the doublure. Each notch is approximately semicircular in outline.

The smallest cranidium of this species so far identified (plate 63, fig. 25) is approximately 0.5 mm. in length (sag.). The glabella is narrower and more nearly cylindrical than in the adult, and the nasute cranidial rim is not yet developed. The cranidial outline is sub-trapezoidal and relatively narrower posteriorly than that of the adult.

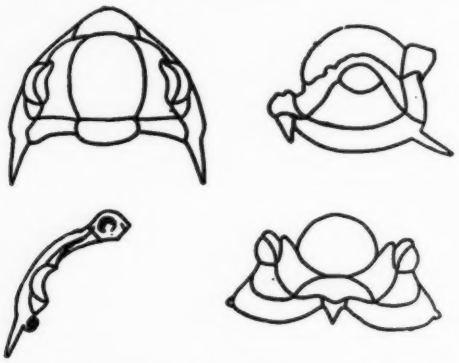

FIG. 1—*Dimeropygiella caudanodosa* Ross. Reconstruction of the cephalon, showing the rostrum. Based on specimens YPM 18769, 18770. Pustulose ornamentation not shown. Zone "J", locality 13.

Palpebral rims are barely developed. The preglabellar field is longer (sag.) than that of the adult and bears a strong median furrow. Five strong pustules are evenly spaced outside each dorsal furrow. Four pairs of pustules are located on the glabella anterior to the occipital furrow. Others are placed in pairs away from the midline on the anterior rim and lengthwise on the palpebral rims. The arrangement of these pustules, especially on the glabella, is similar to that found in species of *Hystricurus* and *Parahystricurus* at an equally immature stage and may be related to segmentation.

Figured specimens.—YPM Nos. 18769–18770.

Occurrence.—Zone "J," Locality 13, Round Hill, Mantua, Utah (Ross, 1951a, pp. 22–25). *Pseudocybele nasuta* zone of Hintze (1952).

Genus PARAHYSTRICURUS Ross, 1951

PARAHYSTRICURUS sp.

Plate 63, figures 27, 31

Description.—Two cranidia and one free cheek, none well preserved, of this genus have been found high in the "G" zone of the Garden City formation (Ross, 1951a, p. 28) equivalent to high *Protopliomerops contracta* zone of Hintze (1952); their main importance is stratigraphic, for they indicate that the generic range must be extended upward.

Both the cranidium and free cheek bear a close resemblance to those of *P. pustulosus* (Ross, 1951a, p. 60), with which they may be conspecific. However, all are very small specimens, and it is virtually impossible to distinguish between cranidia of the known species of the genus when they are less than 1.2 mm. in length; when larger specimens of this species are found it may be possible to reach a more lasting conclusion regarding its specific assignment.

Figured specimens.—YPM Nos. 18772, 18773.

Occurrence.—High "G" zone, locality 6, (Ross, 1951a, p. 16–17); equals high *Protopliomerops contracta* zone of Hintze (1952). Based on corrected measurement 775 feet stratigraphically above the base of the Garden City formation; located at slope distance of 2,966 feet southward along crest of ridge from the base of the formation.

Genus PSALIKILOPSIS Ross, n. gen.

Description.—This opisthoparian genus possesses a transversely elliptical, strongly convex cephalon; the ocular platforms of the free cheeks are strongly deflexed, and the median portion of the anterior rim is uparched so that the margins are "rocker-shaped" when seen in lateral view. The subglobular glabella is devoid of glabellar furrows and is perched above subhorizontal, nearly flat fixed cheeks. The preglabellar field is strongly deflexed, being shorter sagittally than exsagittally and possessing a prominent transverse, convex roll. The cephalic rim is sub-tubular and defined proximally by a distinct marginal furrow. The occipital ring is very short sagittally, the occipital furrow being deep; a median tubercle is present on the ring. The axial furrows are confluent around the front of the glabella, are sharp, but are not deep. In shape and position the palpebral lobes are *Hystricurus*-like, as is the shape of the pos-

terolateral limbs. Genal spines are based far forward from the intersection of the facial sutures and the posterior margin.

The pygidium is composed of a prominent, tapering axis of four rings, on either side of which are flat, furrowed, narrowly triangular pleural platforms; the platforms are limited distally by an abrupt change in slope to very steep smooth surfaces; there is no marginal furrow; the semitubular margin is upswept at the midline in an obtusely V-shaped form.

The hypostome is not known, nor are the thoracic segments certainly identified.

Genotype.—Psalikilopsis cuspidicauda Ross, n. sp.

Discussion.—Previously specimens of this genus were recognized and placed tentatively within the genus *Psalikilus* without specific designation (Ross, 1951a, p. 63, plate 13, figs. 33, 34, plate 30, figs. 1–3). The difference in development of the terminal spine of this previously noted species suggests that it is not conspecific with the genotype and that there are at least two species present within the *Protopliomerops contracta* zone; the difference cannot be attributed to preservation or ontogenetic stage. Since the two were collected from two different localities geographic variation may be considered as a possible explanation.

Psalikilopsis resembles *Psalikilus* strikingly in the shape and orientation of the preglabellar field, in the shape of the palpebral rims, and in the basic form of the pygidium. It differs in the shape of the glabella and complete lack of vestiges of glabellar furrows. It resembles *Hystricurus* in the form of the palpebral lobes and rims, which in both genera are located opposite the glabellar midpoint; it differs in the degree of deflexion of the preglabellar field, uparching of the rim, shape of the glabella, horizontality and flatness of the fixed cheeks, and form of the pygidium. Although it compares much more favorably with species assigned to *Pseudohystricurus* as regards the features of the glabella and deflexion of preglabellar field, it differs in outline of the palpebral rims, shape of the posterolateral limbs, and uparching of the anterior rim. *Psalikilopsis* also bears some resemblance to *Petigurus*, but in the latter the glabella overhangs a very short (sagittally) preglabellar field and the pygidium is far different in outline and construction.

The striking similarity between pygidia of *Psalikilopsis* and those assigned to species of *Psalikilus* (Hintze, 1952) suggests that these two genera are in some way related. Other pygidia from the lower "E" zone (*Tesselacauda depressa* zone, Ross, 1951a, plate 19, figs. 8–9), which may belong to one of the species of *Amblycranium* Ross, are also similar; one is tempted to speculate on the possible inter-relationship between all of these forms.

PSALIKILOPSIS CUSPIDICAUDA Ross, n. sp.
Plate 63, figures 2–9, 12

Description.—The surface of the carapace is finely pustulose except for the marginal rims of the cephalon and pygidium and the palpebral rims. The inflated glabella is two-thirds as wide as long and one-third as high as long; its length equals approximately eight-tenths of the maximum cranidial length (exsag.), and on a line through the eye centers occupies one-half its width. The posterior tenth of the glabella is devoted to the occipital ring, which comprises the widest (tr.) portion. A median pustule is located on the edge of the deep occipital furrow. The brim (preglabellar field) is deflexed at an angle close to 60° from the glabellar base; its sagittal length is approximately one-fifth that of the glabella, while its maximum width (tr.) equals the glabellar length (sag.). The narrow (sag.), subtubular rim is bounded proximally by a shallow marginal furrow. The ex-sagittal length of the palpebral lobes approaches half the sagittal length of the glabella; very shallow palpebral furrows set off well-developed, asymmetrically but sharply curved rims. The posterolateral limbs are narrowly triangular, the length (tr.) of each equalling two-thirds the glabellar width (tr.) at the occipital ring.

Anteriorly the facial sutures diverge and then converge sharply before reaching the marginal furrow, so that the cranidial width immediately in front of the palpebral lobes equals its width at the anterior rim. The sutures cross the rim on a shallow diagonal, running inward and upward (plate 63, figs. 3, 5).

Free cheeks, hypostome, and thoracic

segments are not certainly known. A rostrum may have been present.

The pygidium is roughly triangular in dorsal outline, possessing a tapering, prominent axis of four rings, of which the anterior one is longest (sag.). An articulating half-ring and anterolateral facets are well developed. The pleural platforms proper are not continuous around the rear end of the axis and are marked by three furrows. A terminal spine is rooted immediately below the end of the axis; its length is six-tenths the sagittal axial length. The spine curves gently ventrad. The distal sides of the pygidium are very steep, sloping outward; they are unfurrowed and appear to represent a special modification of the rim. Beneath the terminal spine the rim is drawn upward (plate 63, fig. 6). The doublure is very narrow and semitubular.

Holotype.—YPM No. 18774. Paratypes, YPM Nos. 18775–18778.

Occurrence.—Middle zone "G," locality 6, Garden City formation (Ross, 1951a, pp. 16–17). Based on corrected 1949 field measurement 668–689 feet stratigraphically above the base of formation; located at slope distance of 2,537–3,633 feet southward along crest of ridge from base of formation.

Discussion.—This species is congeneric with and differs from "*Psalikilus*" sp. (Ross, 1951a p. 63, plate 13, figs. 28, 29, 33, 34; plate 30, figs. 1–3) only in the length of the terminal pygidial spine, a difference which cannot be attributed to ontogenetic stage. Unfortunately no free cheeks have been collected for *P. cuspidicauda*, so that it is not possible to draw conclusions concerning a rostral plate although the suture beneath the cranidial rim suggests that one was present. Associated thoracic segments show that the pleura are deeply grooved and that a narrowly V-shaped Panderian opening is directed posteroproximally.

Pygidia of this species are strikingly similar to those of various species of *Psalikilus* (Ross, 1951a, plate 30, figs. 11, 15; Hintze, 1952, plate 20, fig. 15, and plate 9, fig. 7), as well as to an undescribed form from a lower zone (Ross, 1951a, plate 19, figs. 8–9). Although a close relationship is suggested, the complete lack of glabellar furrows, even on the ventral side of the carapace (plate 63, fig. 3) does not permit its assignment to *Psalikilus*.

The fragmentary cranidium illustrated by Hintze as *Jeffersonia* ? sp. (1952, plate 9, fig. 11) may belong to this genus. The cheek and pygidium assigned to it by him are believed to belong elsewhere on the basis of associations in the same zone of the northeastern Utah sections.

Genus PSEUDOHYSTRICURUS Ross, 1951

PSEUDOHYSTRICURUS ORBUS Ross, n. sp.

Plate 63, figures 10–11, 13–20, 23

Description.—The cephalon is sub-semicircular in outline, strongly convex in lateral profile, and possesses a pustulose surface. The glabella is sharply rounded in anterior

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EXPLANATION OF PLATE 62

FIGS. *1, 2, 5*—*Kawina sexapugia* Ross. Zone "J," locality 13. *1*, meraspid cranidium, ×30. YPM 18752. *2*, protaspid, ×30. YPM 18751. *5*, meraspid pygidium, ×30. YPM 18753. (p. 644)

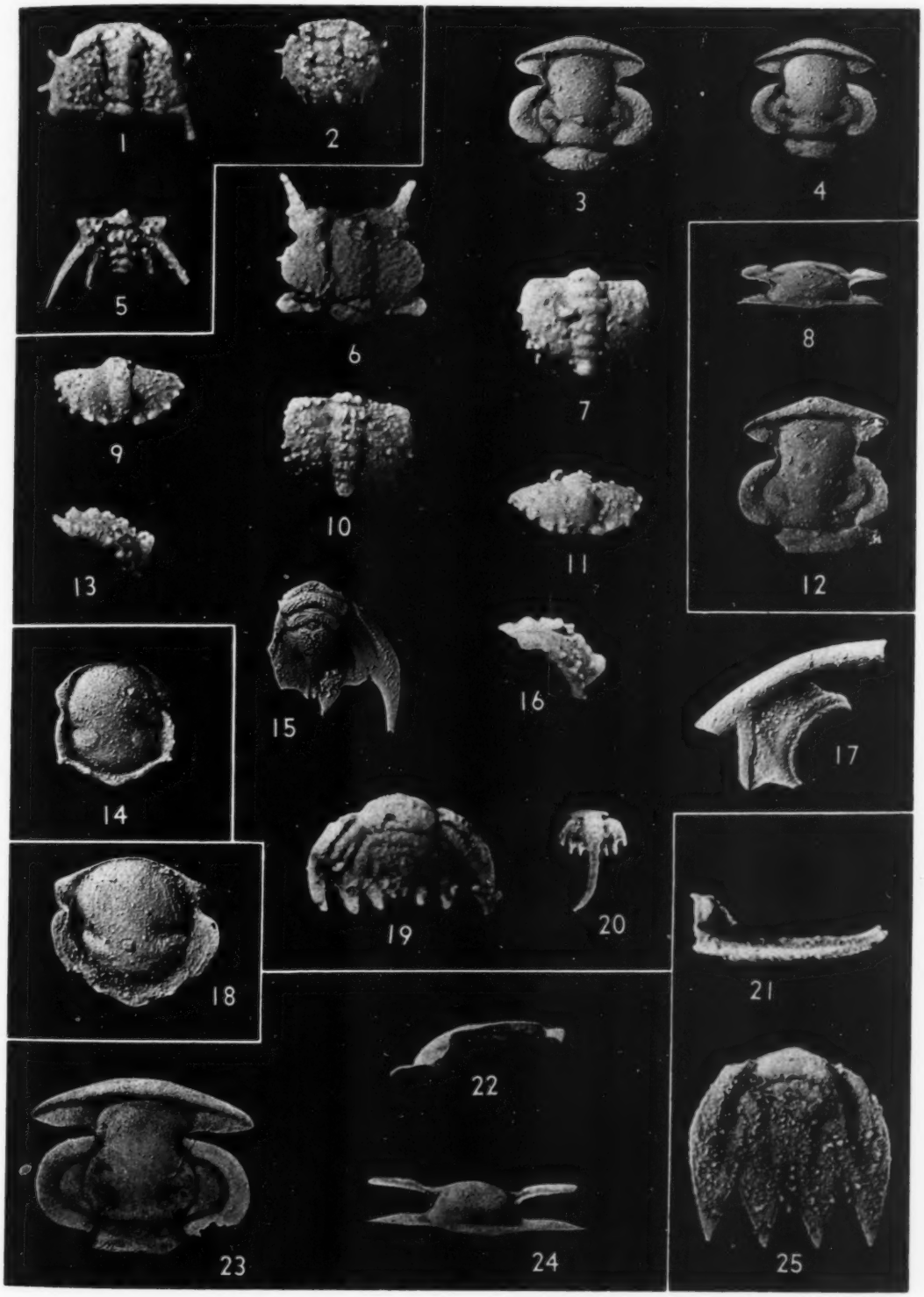
3, 4, 6, 7, 9–11, 13–17, 19–20—*Menoparia genalunata* Ross. Zone "G(1)," locality 6. *3*, immature cranidium, ×10. YPM 18759. *4*, cranidium, ×7, showing extreme narrowness of crescentic fixed cheek. YPM 18760. *6*, meraspid cranidium, ×25. YPM 18756. *7, 11, 16*, meraspid (?) pygidium, dorsal, posterior, and lateral views, ×25. YPM 18757. *9, 10, 13*, meraspid (?) pygidium, posterior, dorsal, and lateral views, ×25. YPM 18758. *14*, hypostome, questionably assigned to this species, ×10. YPM 18754. *15*, fragmentary pygidium, showing double median spine, ×7. YPM 18761. *17*, free cheek, ventral view showing doublure, ×10. YPM 18762. *19*, immature pygidium, ×25. YPM 18763. *20*, immature pygidium, ×15. YPM 18765. (p. 634)

8, 12—*Apatokephalus* ? sp. Zone "G(1)," locality 6. Cranidium, anterior and dorsal views, ×7. YPM 18767. (p. 636)

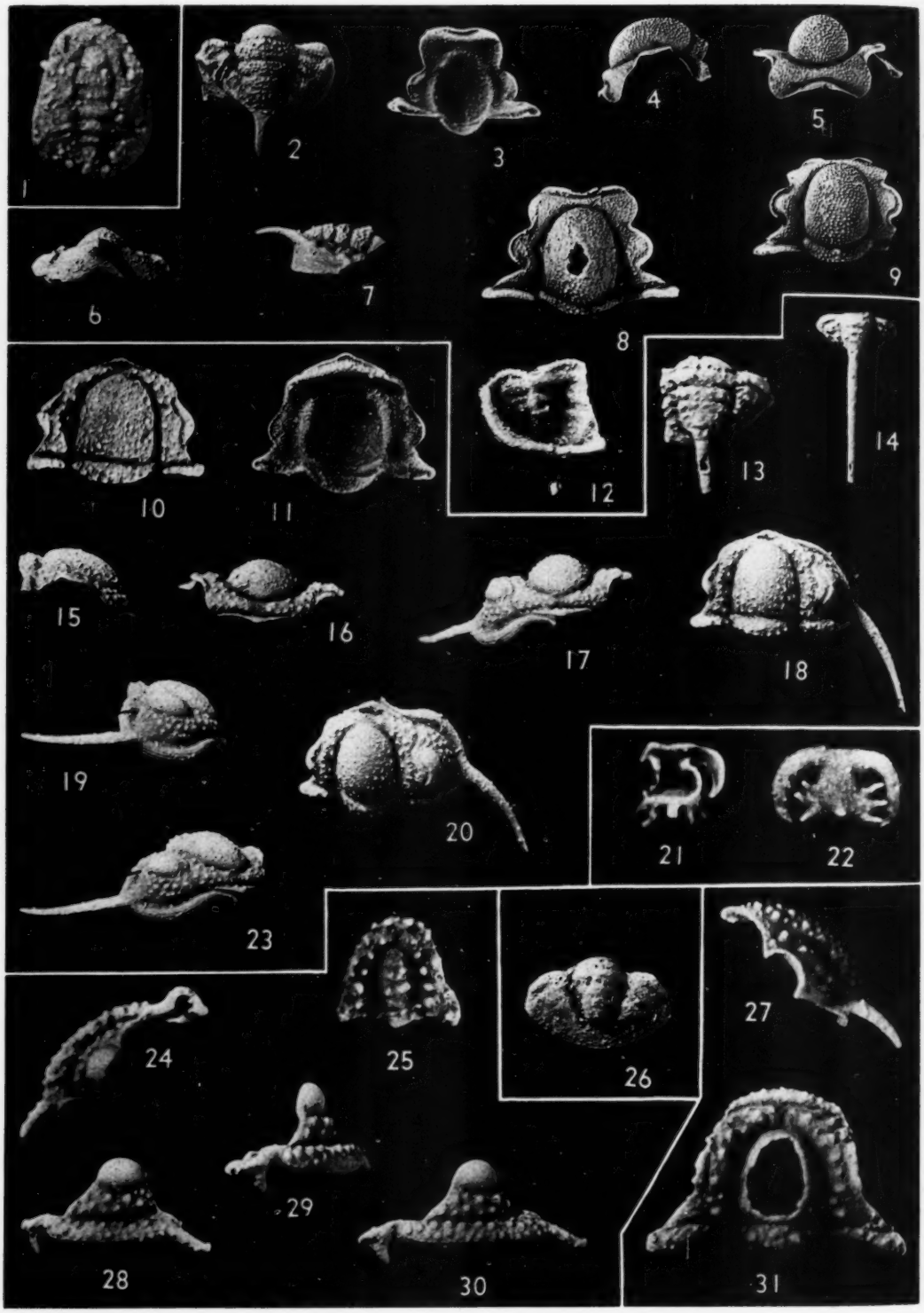
18—Hypostome associated with *Menoparia genalunata*, but here assigned to *Megalaspidiella* sp. Zone "G(2)," low, locality 6. Ventral view, ×10. YPM 18755. (p. 634)

21, 25—*Scinocephalus quadrihastatus* Ross, n. sp. Holotype. Low zone "G(2)," locality 6. Lateral and dorsal views, ×15. YPM 18768. (p. 637)

22–24—*Menoparia lunalata* Ross, n. sp. Holotype. High zone "G(2)," locality 6. Lateral, dorsal, and anterior views, ×6. YPM 18766. (p. 635)



Ross, Ordovician Garden City trilobites, Utah



Ross, Ordovician Garden City trilobites, Utah

outline, low, evenly rounded in anterior profile, and devoid of all but the occipital furrow. Its length (sag.) occupies 0.85 of the cranidial length; its width on a line between the eye centers is three-fourths that of the cranidium. The occipital ring, taking up eight-tenths of the glabellar length (sag.), bears a minute medial pustule on its anterior edge and is set off by a deep furrow. The strongly convex, transverse roll of the brim (preglabellar field) is divided by a shallow, wide, sagittal furrow. The marginal furrow is deep and narrow and sets off a subtubular rim, ornamented with concentric Bertillon lines. The fixed cheeks are convex, as in most species of *Hystricurus*. Distinct palpebral furrows bound very slightly curved palpebral rims. A transverse line between the posterior ends of the rims crosses the glabella a very short distance behind its midpoint. Facial sutures anterior to the eyes converge slightly with little curvature to the marginal furrow, turn sharply inward to revolve across the dorsal side of the rim, and meet at an obtuse point on the anterior margin. Posteriorly the sutures diverge, running straight from the rear of the eyes to cut the posterior margin well within the genal spines.

The free cheeks have strongly convex ocular platforms, rotund eyes, and gently curved, long genal spines. An infra-ocular ring is apparently lacking. The genal spines appear to take root from the distal edge of the ocular platform or dorsal side of the rim, for the rim passes uninterrupted beneath their bases. The anterior median portion of the rim and doublure are curved downward to fit beneath the obtusely angular front of the cranidium, but the downward curve close to the midline is accentuated to a greater degree than can be explained by the shape of the cranidial form alone. This fact, plus the fact that a free cheek fitted into place (plate 63, figs. 17, 20, 23) does not reach entirely to the midline, strongly suggests that a rostrum of unknown shape was present. Neither Pander's organs nor articulating notches are present on the doublure of the free cheeks.

The pygidium tentatively assigned is identical to that figured by Hintze (1952, plate 20, fig. 16). This type is characterized by a tapering axis of four rings, the fourth terminating in a long spine. Pleural platforms are curved evenly downward, marked by three pairs of furrows, and bounded by a faint marginal furrow and narrow subtubular rim. The latter passes without interruption beneath the terminal spine.

Holotype.—YPM No. 18779. Paratypes. —YPM Nos. 18780–18783.

Discussion.—This species differs from all three previously described (Ross, 1951a, pp. 74–75) in the course of the facial sutures across the anterior rim and in the resulting nasute appearance of the cranidium. From *P. rotundus* it is also differentiated by the possession of a preglabellar median furrow. Because of the greater width (tr.) and con-

EXPLANATION OF PLATE 63

FIG. *1*—*Licnocephala cavigladius* (Hintze). High zone "G(2)," locality 6. Metaprotaspid, ×30. YPM 18787. (p. 642)

2–9, 12—*Psalikilopsis cuspidicauda* Ross, n. gen., n. sp. Low zone "G(2)," locality 6. *2, 6, 7*, pygidium, dorsal, posterior, lateral views, ×6. YPM 18777. *3*, cranidium, ventral, ×7. YPM 18776. *4, 5, 9*, holotype cranidium, lateral, anterior, and dorsal views, ×3. YPM 18774. *8*, paratype cranidium, dorsal, ×5. YPM 18775. *12*, pygidium, ventral, ×10. YPM 18778. (p. 639)

10–11, 13–20, 23—*Pseudohystricurus orbus* Ross, n. sp. Zone "G(1)," locality 6. *10, 15, 16*, holotype cranidium, dorsal, lateral, and anterior views, ×8.6. YPM 18779. *11*, paratype cranidium, ventral, ×10. YPM 18780. *13*, pygidium, ×10. YPM 18782. *14*, pygidium, ×10. YPM 18783. *17–20, 23*, cranidium, YPM 18780, and free cheek, YPM 18781, glued together; anterior, dorsal, lateral, anterodorsal, and anterolateral views, ×8. (p. 640)

21, 22—Incertae sedis. Hypostomes, immature and unassigned. High zone "G(2)," locality 6, *21*, dorsal view, ×30. YPM 18785. *22*, ventral view, ×30. YPM 18786. (p. 645)

24–25, 28–30—*Dimeropygiella caudanodosa* Ross. Zone "J," locality 13. *24, 28–30*, free cheek with rostrum, dorsal, lateral, anterior, and anterolateral views, ×15. YPM 18769. *25*, meraspid cranidium, ×30. YPM 18771. (p. 637)

26—Unidentified pygidium, ×6. Zone "G(1)," locality 6. YPM 18784. (p. 642)

27, 31—*Parahystricurus* sp. High zone "G(2)," locality 6. *27*, free cheek, ×20. YPM 18773. *31*, cranidium, ×20. YPM 18772. (p. 638)

vexity of the fixed cheeks there was originally question in this author's mind as to congenerity of the four. The suggestion of rostrum and difference in facial sutures may eventually support this question.

The pygidial assignment may also be questioned since a second type (plate 63, fig. 26) is found associated. This same combination has been reported by Hintze (1952, plate 9, fig. 8 and plate 20, fig. 16; personal communication) from the same faunal zone. Because of ornamentation the assignment made here is certainly correct.

Occurrence.—Basal "G" zone, locality 6, Garden City formation (Ross, 1951a, p. 16), 580 feet stratigraphically above the base of the formation; located at a slope distance of 2,140 feet southward along the crest of the ridge from the base of the formation.

Genus LICNOCEPHALA Ross, 1951

As originally described this genus was monotypic and was based primarily on the genotype, *L. bicornuta* Ross (1951a, pp. 109–111). It seems advisable that two other species *L. cavigladius* (Hintze) and *L. ovata* Ross, n. sp., be included within its scope and that the generic diagnosis be altered accordingly.

It also becomes evident that the characters of the facial sutures at the anterior margin were erroneously interpreted, for the available free cheek of the genotype had been broken along the median portion at the anterior end (Ross, 1951a, plate 28, fig. 12). It appears certain that the facial sutures terminate at the anterior edge of the cephalon, that a transverse suprarostral suture connects them just below the edge of the margin (plate 64, fig. 4), and that a pair of posteroproximally directed sutures separate the cheeks from a rostrum (plate 64, figs. 10, 24). Actually it is not possible to demonstrate this for the genotype, nor has a rostral plate as yet been found for the species described below. The sutural pattern is so similar between the two that there can be little doubt of the correctness of the present revised interpretation.

It may also be noted that a hypostome is known for *L. cavigladius* (Hintze) (plate 64, figs. 11–13, 16–17; Hintze, 1952, plate 10, fig. 3) of unusual construction; that the genotype possesses a similar structure can only be assumed at present.

If the generic concept is altered to include *L. cavigladius* (Hintze) and *L. ovata* Ross, n. sp., it becomes obvious that the glabellar shape is far more variable than many investigators would allow within a single genus. The alternative would be to create three genera, each monotypic, a course which at present has few advantages. Until all the skeletal parts of all three species are known their congenerity can be neither proved nor disproved.

The possible bathyurid affiliations of the genus are discussed under *L. cavigladius* (Hintze), below.

LICNOCEPHALA CAVIGLADIUS Hintze

Plate 63, figure 1; plate 64, figures 4–29

Licnocephala ? cavigladius HINTZE, 1952, pp. 190–192, pl. 10, figs. 1–5.

As mentioned by Hintze (1952, p. 192) it is this author's opinion that this species should be assigned, at least tentatively, to the genus *Licnocephala*. This assignment cannot be considered final for there are many points of difference between it and the genotype. It is clear, however, that *L. cavigladius* is not closely related to *Niobe* and similar asaphids, since it certainly must possess a rostral plate. The following remarks concerning the rostrum are probably equally applicable to *L. bicornuta* Ross, for which the evidence is not as well documented.

Rostrum and facial sutures.—Although no actual rostral plate has been secured, its presence is required by two conditions. In the first place a dorsal reconstruction of the cephalon based on the free cheeks alone will produce far too narrow a cranidial outline unless a rostrum is interposed between the two. In the second place there is no evidence for an hypostomal suture of the proper form (plate 64, figs. 6, 10, 11, 17, 24) along the edge of the doublure. From the cut of the diagonal sutures which limit the anteroproximal tips of the free cheeks it appears that the rostral plate must approach the shape of a trapezoid in which the anterior of the two parallel sides is the longer.

The facial sutures anterior to the eyes curve inward after attaining the marginal furrow and reach the margin. There they

are connected by a transverse suprarostral suture immediately below the margin (plate 64, fig. 4). Each is also met by a diagonal suture which separates the doublure of the free cheek from the inferred rostrum (plate 64, figs. 10, 24). This condition is believed to be true for *L. bicornuta* also.

Hypostome.—A remarkably preserved hypostome of this species (plate 64, figs. 12–13, 16–17) is worthy of special note. It is equipped with a forward pair of enormously elongated, slender appendifers and a more posterior pair of short processes both directed dorsally from the edge of the structure. Both are hidden in ventral view by the wide, hollow "lateral wings," if such they can be called. It appears probable that the anterior pair of appendifers was attached beneath the dorsal furrows near the front of the glabella, although no points of attachment are evident (plate 64, fig. 4). Because of the sharp upward bend of the anterior tongue of the hypostome (plate 64, fig. 13) its position must have been nearly horizontal; the tips of the appendifers suggest that the structure sloped gently posterodorsally, a position which would also bring the shorter posterior processes close to the dorsal shield.

Ontogenetic development.—The smallest individual assigned with any confidence to this species (plate 63, fig. 1) is a metaprotaspid lacking the free cheeks. The cranidial outline is almost triangular and clearly opisthoparian. The glabella is more distinct than at any other stage in the development; five rings are present, including the occipital ring, but the furrow separating the two most anterior rings is little more than a barely perceptible constriction. The position of the eyes can be inferred, but no palpebral lobes are developed. The pygidium is sub-semicircular, as is that of the adult stages. In the axis only two rings can be made out, although there is a suggestion of three pairs of pleural tips along the margin. Other details are obscured by grains of silt which cannot be removed.

Cranidial development is illustrated on Plate 64 in the following sequence: figures 14, 8, 18, 20, 15, 23, and 7. During this ontogeny the facial sutures and the transverse connecting suture change little except to delimit more and more pronounced palpebral lobes and increasingly slender posterolateral limbs. The glabella is low and poorly defined throughout; the furrows are lost almost immediately, the occipital furrow alone being retained until cranidia are over 1.15 mm. long (plate 64, fig. 8).

Pygidial development has not been completely traced, but appears to show little change. Five axial segments are attained before the pygidial length (sag.) is 2.0 mm. (plate 64, fig. 29) as is the wide doublure.

Figured specimens.—YPM Nos. 18787–18804.

Discussion.—The presence of a rostrum in this species is of special interest inasmuch as its dorsal characters are compatible with many trilobites of the asaphid type, with which it obviously should not now be allied. Although the hypostome might be taken for one of the unforked asaphid varieties, in all of these the anterior wings are short and broad (as in *Bellefontia* (Ross, 1951a, plate 26, figs. 1–4)) and in none is there a similar dorsally directed anterior tongue. The slender anterior appendifers of this species are not unique. They are known also in *Eleutherocentrus petersoni* Clark and in *Goniotelina williamsi* (Ross) (Whittington and Ross, this issue). Both of these species also possess rostral plates and are considered bathyurid. It then seems probable that *Licnocephala* is also a bathyurid trilobite.

That many other trilobites have hypostomes equipped with similar structures is likely. Unless specimens are silicified and capable of being etched free from the enclosing rock the chance of preservation of these slender appendifers is virtually nil; on only one of a score of silicified hypostomes in the present collections were they found intact.

In undertaking the study of the ontogeny of this species it was hoped that the sutural development might be followed and that some light might be thrown on the question of opisthoparian-proparian beginnings. That the facial sutures do crowd closer to the glabella immediately in front of and behind the eyes is obvious, but this is not unexpected. That metaprotaspids of a size illustrated in Plate 63, fig. 1 are already opisthoparian in character is clear, but of younger stages nothing is certain. Even at this size it is extremely difficult to distin-

guish between several species, which in the adult stages are certainly only distant relatives; in smaller stages distinctions are virtually impossible.

Occurrence.—High in zone "G(2)," locality 6, Garden City formation (Ross, 1951a, pp. 16–17); located at a slope distance of 2,966 feet southward along the ridge from the basal exposures of the formation, computed to be 775 feet stratigraphically above the base.

LICNOCEPHALA OVATA Ross, n. sp.
Plate 64, figures 1–3

Licnocephala ? sp. Ross, 1951, Peabody Mus. Nat. Hist. (Yale), Bull. 6, pp. 111–112, plate 28, figs. 4, 5, 9.

Description.—Little need be added to the original description of this species other than to note that the anterior end of the glabella and the brim in front of it do not bear a raised crease; as previously suggested (Ross, 1951a, pp. 111–112) this feature appeared to be the result of lateral compression of a secondary nature. Rare specimens found throughout the "G(2)" zone indicate that this is indeed the case.

It is also clear from these better preserved specimens that a short (sag.), poorly defined occipital ring is present at the rear of the semi-ovoid glabella. The facial sutures behind the palpebral lobes run anterolaterally before curving sharply to the rear across the posterior margin; the resulting posterolateral limbs are so slender at the dorsal furrows that they are seldom found entire.

Holotype.—YPM No. 18805.

Discussion.—This species differs markedly from the genotype, *L. bicornuta* Ross, in the size of the glabella and palpebral lobes, but there is actually little difference in the shapes of these features. With the exception of the form of the glabella it is strikingly similar to *L. cavigladius* (Hintze), in which the glabella is more nearly rectangular in outline and in which no occipital furrow is known in cranidia over 1.2 mm. in length (sag.).

Because the holotype is associated with specimens of *L. cavigladius* described above it is entirely possible that some of the illustrated free cheeks and pygidia may belong to this species. No satisfactory means was found that might show a distinction. The possibility that the cranidia assigned to the other species belong here is obviated by range of sizes in the ontogeny, which includes that of the holotype.

Occurrence.—Zone "G(2)," locality 6, Garden City formation (Ross, 1951a, pp. 16–17, 112). Holotype secured 775 feet above the base of the formation 2,966 feet southward along the ridge from the basal exposure. Lowest occurrence of species, based on revised measurement of section, is approximately 600 feet above formation's base, 2,270 feet south of basal exposure.

Genus KAWINA Barton, 1915
KAWINA SEXAPUGIA Ross
Plate 62, figures 1, 2, 5

Kawina sexapugia Ross, 1951, Peabody Mus. Nat. Hist., (Yale), Bull. 6, pp. 127–129, plate 35, figs. 6, 7, 11–17, 19–21.

Only a single protaspid specimen (plate 62, fig. 2) has been assigned with any assurance to this species. It bears a close resemblance to those of *Protopliomerops* (Ross, 1951a, pp. 145–148, fig. 4b; plate 32, figs. 2, 3, 4) and *Pseudocybele* (Ross, 1951b, pp. 583–584, plate 82, figs. 3–7), but differs from both in the greater width of the axial lobe, in the more posterior position of the anterior rim in front of the glabella. There is the vaguest suggestion of a median crease dividing the incipient glabella into a right and a left half.

Meraspid cranidia (plate 62, fig. 1) differ little from those of the other two proparian genera; however, it will be noted that in both the protaspid and meraspid stages an imaginary transverse line connecting the bases of the antero-lateral spines crosses the glabella between the second and third segments (from the front), while on *Protopliomerops* and *Pseudocybele* such a line passes one segment farther forward. The difference in position of the eyes which is so clear in the adults therefore manifests itself even in the smallest individuals.

The only assignable meraspid (or metaprotaspid) pygidium (plate 62, fig. 5) possesses five axial segments, of which the first bears an enormous pair of spines. The spines of the second are about half as long. On the third segment the spines are minute, while those of the fourth are virtually non-exist-

ent. No spines are located on the fifth terminal segment. Of special interest are two pairs of puncta, one pair on each side of the axis on the anterior pair of pleura. These are obviously the forerunners of the similar features of the adult (Ross, 1951a, plate 35, fig. 21).

Figured specimens.—YPM Nos. 18751–18753.

Occurrence.—Zone "J" (or *Pseudocybele nasuta* zone of Hintze (1952)), locality 13, Round Hill, north of Mantua, Utah. (Ross, 1951a, pp. 22–23, 129.)

INCERTAE SEDIS

Unidentified protaspid hypostome

Plate 63, figures 21, 22

Very peculiar, minute hypostomal structures have been known in the silicified Garden City material from the high "G" and "J" zones since original investigations were undertaken. Although their specific and generic assignment is still in doubt they are of so unusual a form as to warrant their description.

Description.—The over-all dimensions of the entire structure are about 0.3 mm. in length (sag.) and 0.6 mm. in width (tr.). The middle body is strongly convex and constricted anteriorly; laterally directed are three pairs of stout spines. A single median spine is located posteroventrally. No rim, transverse furrows or maculae are developed. At the anterior end is a pair of enormous crescentic processes, which curve laterally and strongly posteriorly past the tips of the posterolateral spines. The anterior (and dorsal) edge of the structure from the tip of one crescent to the tip of the other is clearly of a sutural character. On the dorsal side at the narrowest part of the structure, immediately behind the bases of the crescents, is a pair of extremely minute raised nubs; these nubs are here believed to be either true, but undeveloped, anterior wings or articulating devices of the hypostome proper.

Figured specimens.—YPM Nos. 18785, 18786.

Discussion.—The small size of all of these structures has hampered any successful determination of their specific assignment, but it is fairly clear that they belong to an extremely immature stage of development, certainly protaspid. It is also important to note that most specimens are found lacking the anterior crescents and appear to have been broken or to have become disarticulated along a straight transverse suture immediately behind the crescents. Although the separation is always clean and straight it is impossible to make out a suture on the complete specimens; nevertheless a suture is here believed to exist.

Because of the above facts and inferences it was immediately postulated that the crescentic structures were rudimentary free cheeks with the hypostome attached. The most likely forms to which the structure might belong appeared to be proparians—*Pseudocybele* and *Protopliomerops*. All known growth stages of both these genera indicate that the eyes are well developed in the smallest identified forms (Ross, 1951b, p. 583, plate 83, figs. 13, 17). Since there are no identifiable eyes on the crescents, and since hypostomes have been found of almost equally small size for both proparian genera, this possiblity has been placed in doubt.

Until very recently it has been this author's alternate conviction that these structures belonged to species of *Dimeropygiella* or one of the other undescribed, related species from slightly lower strata with which they are associated. This conviction was based primarily on ornamentation, and required that the crescentic portions should be a part of the hypostomal or rostral structure; because very small cranidia and free cheeks of these dimeropygid species were already known, it seemed probable that the crescentic structures would have to fit a continuous suture along the cephalic doublure. Some strength was added to this alternative by association, for both Whittington and Evitt (personal communications) had found the same type of structure in association with species of *Dimeropyge*, in younger formations.

A very recent communication from Evitt indicates that these peculiar little hypostomal structures probably do not belong to any of the dimeropygid forms but either to associated proparians or some other opisthoparian. Evaluation must await the results of his study.

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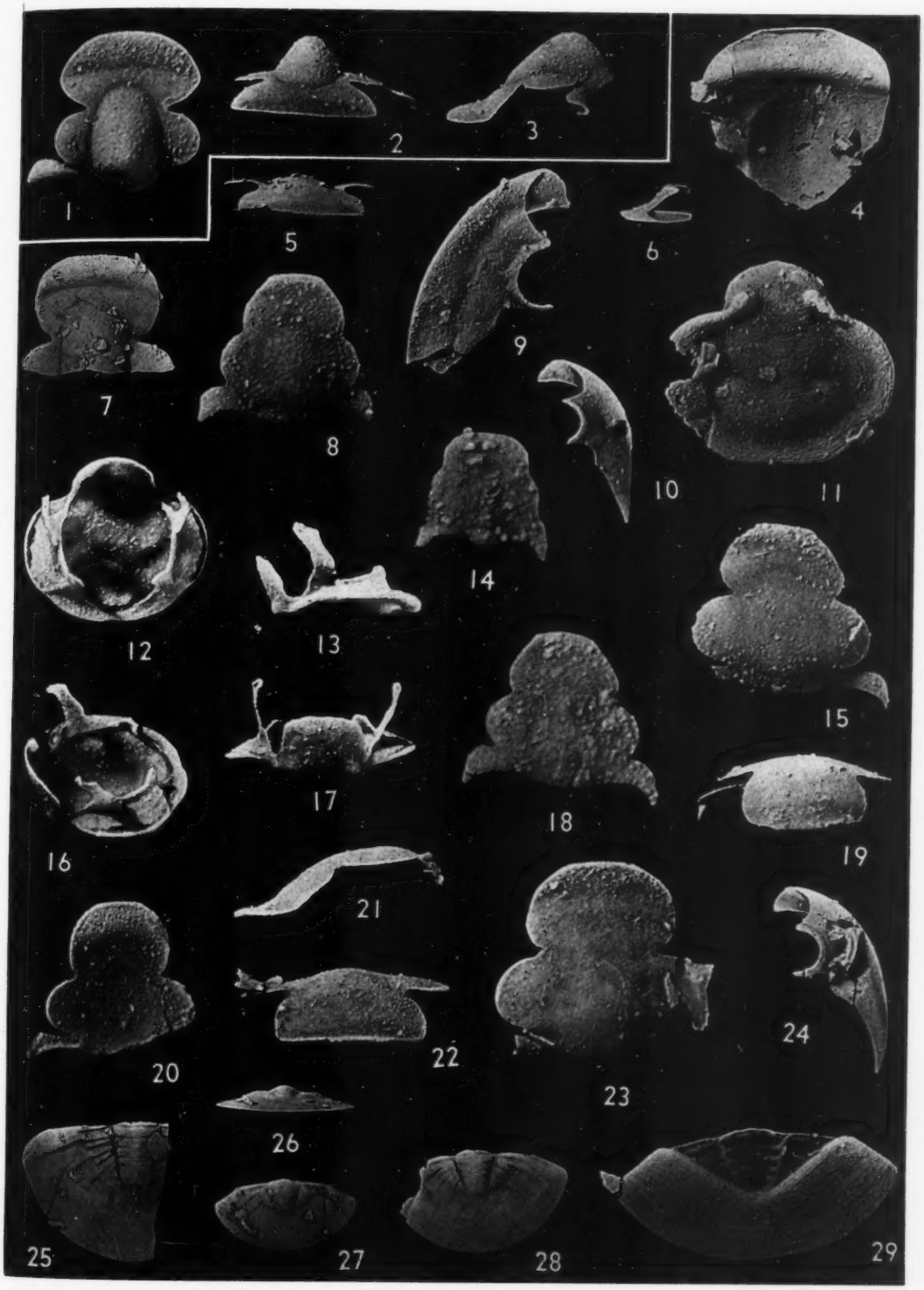
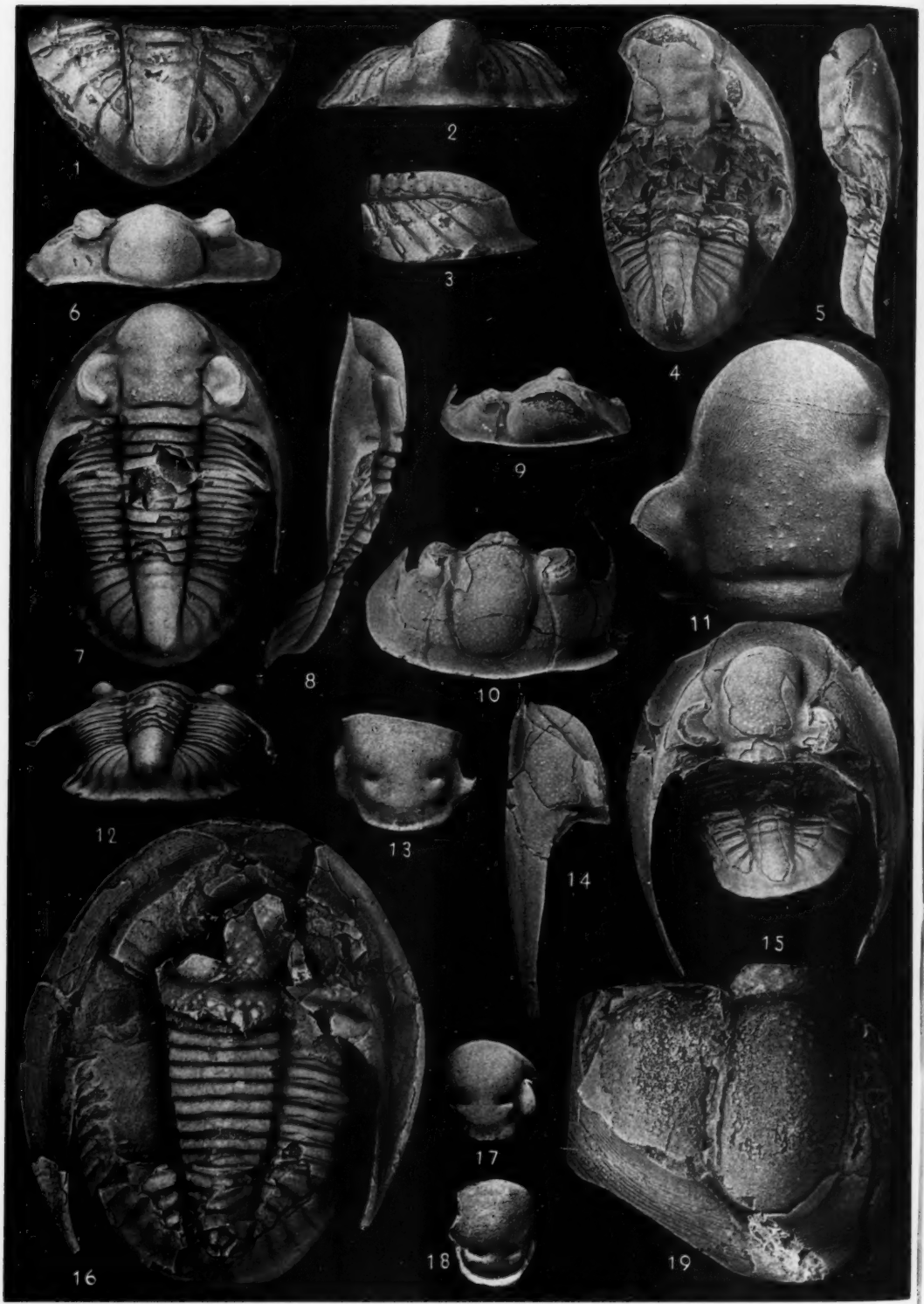
EXPLANATION OF PLATE 64

FIGS. *1–3*—*Licnocephala ovata* Ross, n. sp. High zone "G(2)," locality 6. Holotype cranidium, dorsal, anterior, and lateral views, ×10. YPM 18805. (p. 644)

4–29—*Licnocephala cavigladius* (Hintze). High zone "G(2)," locality 6. *4*, cranidium, anterior ventral, ×4. YPM 18795. *5*, *7*, cranidium, anterior and dorsal views, ×3.5. YPM 18794. *8*, immature cranidium, ×20. YPM 18789. *9*, immature left free cheek, ×10. YPM 18798. *6*, *10*, immature right free cheek, anterior and dorsal views, 10. YPM 18796. *11*, hypostome, ventral view, ×10. YPM 18799. *12*, *13*, *16*, *17*, hypostome, dorsal, lateral, antero-dorsal, and anterior views, ×10. YPM 18800. *14*, immature cranidium, ×30. YPM 18788. *15*, *19*, immature cranidium, dorsal and anterior views, ×10. YPM 18792. *18*, immature cranidium, ×20. YPM 18790. *20*, immature cranidium, ventral view, ×12. YPM 18791. *21–23*, immature cranidium, lateral, anterior, and dorsal views, ×10. YPM 18793. *24*, free cheek, ×8. YPM 18797. *25*, pygidium, ×2. YPM 18801. *26*, *27*, pygidium, posterior and dorsal views, ×4. YPM 18804. *28*, pygidium, ×3. YPM 18802. *29*, pygidium, ventral view, ×10. YPM 18803. (p. 642)



Ross, Ordovician Garden City trilobites, Utah



Whittington, *Bathyurus, Raymondites, Bathyurus*?

JOURNAL OF PALEONTOLOGY, VOL. 27, NO. 5, PP. 647–678, PLS. 65–69, 5 FIGS. SEPTEMBER 1953

NORTH AMERICAN BATHYURIDAE AND LEIOSTEGIIDAE (TRILOBITA)

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with contributions by Reuben J. Ross, Jr., and an Appendix on the Age of the Boulder from St. Antoine de Tilly, Quebec

ABSTRACT—Type specimens of Bathyuridae from the United States and Canada are redescribed, together with additional material. The Bathyuridae are here allied with the Styginidae, Scutellidae and Illaenidae in a new superfamily. Fifteen bathyurid genera are recognized, four new, embracing some 60 species (including Greenland forms). Species range in age from middle Canadian to early Trentonian, with greatest diversity in upper Canadian times. Bathyurids are little known outside North America, perhaps owing more to neglect of this family than actual distribution. In Lower Ordovician times there is a remarkable similarity between the bathyurids from Greenland to the Cordillera. The morphology, evolution and mode of life are briefly discussed.

Two new upper Canadian genera are tentatively placed with four other Upper Cambrian and early Ordovician genera in the Leiostegiidae. Four species, two the types of bathyurid genera, one the type of a leiostegiid genus, and the fourth made the type of a new genus of uncertain affinities, came from the boulder at St. Antoine de Tilly. Available evidence suggests that this limestone boulder was an erratic, and of latest Canadian or early Middle Ordovician age.

INTRODUCTION AND ACKNOWLEDGMENTS

THE present work is in preparation for a contribution to the Treatise on Invertebrate Paleontology. Bathyurid trilobites have been neglected for many years, and accounts of trilobites and trilobite classification in the past 20 years have perforce omitted treatment of them (e.g. Richter, 1932; Stubblefield, 1936; Størmer, 1949; Henningsmoen, 1951). Essential to a restudy of this family was an examination of the material described by Billings (1865), and of the collection in the U. S. National Museum brought together by E. O. Ulrich.

Other material is, apart from C. H. Kindle's collections from Newfoundland, and the few types, generally scanty and of less importance. I have seen no extra-North

EXPLANATION OF PLATE 65

FIGS. *1–9, 11–13, 17*—*Bathyurus extans* (Hall). *1–3*, lectotype, internal mold, original of Hall, 1847, pl. 60, figs. 2a, 2b, dorsal, posterior, and left lateral views, ×1½. Lowville limestone, Mohawk Valley, N. Y. NYSM 4139. *4, 5, 9*, dorsal, right lateral, anterior views, ×1. Lowville, Watertown, N. Y. USNM 318. *6, 7, 8, 12*, anterior, dorsal, left lateral, posterior views, ×1½. Lowville, Great Bend, N. Y. USNM 306. *11*, incomplete cranidium, dorsal view, ×3. Lowville, Watertown, N. Y. USNM 318. *13*, incomplete hypostome, plaster cast, original of Raymond & Narraway, 1910, pl. 15, fig. 8, ventral view, ×2. Black River limestones, Mechanicsville, Ottawa, Ontario. ROMP 18755. *17*, incomplete hypostome, plaster cast, ventral view, ×2. Locality as fig. 13. ROMP 18755. (p. 651)

10, 14–16, 19—*Raymondites longispinus* (Walcott). *10, 14, 15*, holotype, original of Raymond and Narraway, 1910, pl. 16, figs. 12, 13, anterior, left lateral, dorsal views, ×1. Black River limestones, Buck's Quarry, Herkimer Co., N. Y., MCZ 3767. *16*, incomplete exoskeleton, dorsal view, ×1½. The connective sutures are revealed on the anterior cephalic doublure. Larrabee member, Hull formation, Rowland's Mills, 4 mi. west of Saratoga Springs, N.Y., USNM 319a. *19*, anterodorsal view of part of cephalon showing left anterior branch of suture on right side, on left side doublure with right connective suture (partially dotted in black) and part of rostrum, ×3. Black River, 1 mile north of Poland, N. Y. USNM 305a. (p. 654)

18—*Bathyurus ? angelini* Billings. Incomplete hypostome, original of Raymond, 1913, Pl. 7, fig. 5, ventral view, ×2. Beekmantown (?), Grenville, Argenteuil Co., Quebec, GSC 7829. (p. 653)

American material, but, apart from the Greenland species, few trilobites collected outside North America have been referred to bathyurid genera. This may be taken rather as a reflection of lack of published accounts of extra-North American Bathyuridae, than as implying that the family is limited to this continent. Two genera investigated seem not to be bathyurids, and are here placed in the Leiostegiidae. It also seemed desirable to describe the one remaining trilobite species from the boulder at St. Antoine de Tilly, although it is neither a bathyurid nor a leiostegiid, and to include this description in an appendix bringing together the available information about this remarkable boulder.

I have greatly benefited from discussions with Reuben J. Ross, Jr., formerly of Wesleyan University, Middletown, Conn., and Dr. Ross contributed the descriptions and illustrations of *Goniotelina williamsi* and *Strigigenalis abdita*, n. gen., n. sp. We have framed the diagnoses of *Goniotelina* n. gen. and *Strigigenalis* n. gen. together. The remainder of the work is my own, but would not have been possible without the cooperation of various institutions and the help of many individuals. I express my thanks to the following: Dr. G. Arthur Cooper, U. S. National Museum; Mr. Donald W. Fisher, University of Rochester; Drs. H. Frebold and Alice E. Wilson, Geological Survey of Canada, and the Official Photographer, who furnished the photographs forming Pl. 65, fig. 18; Pl. 66, figs. 18–20, 23–25; Pl. 67, figs. 14, 19, 20, 25; Pl. 68, figs. 1, 2, 5, 7; Pl. 69, figs. 26–28; Dr. Madeleine A. Fritz, Royal Ontario Museum of Palaeontology; Dr. Winifred Goldring, New York State Museum; Dr. I. W. Jones, Department of Mines, Quebec; Dr. Cecil H. Kindle, City College, New York; Dr. J. Brookes Knight, U. S. National Museum; Professor Norman D. Newell, American Museum of Natural History; Dr. F. Rasetti, The Johns Hopkins University; Dr. Karl M. Waagé, Yale University. I am indebted to the Harvard Foundation for Advanced Study and Research for a grant which enabled me to visit Ottawa and Washington, D. C., and aided in the preparation of the text-figures.

LOCATION OF MATERIAL

The specimens described and discussed in the following pages are preserved at the institutions designated by the following abbreviations:

AMNH—American Museum of Natural History, New York, N. Y.
GSC—Geological Survey of Canada, Ottawa, Ontario.
MCZ—Museum of Comparative Zoology at Harvard College, Cambridge, Mass.
NYSM—New York State Museum, Albany N. Y.
ROMP—Royal Ontario Museum of Palaeontology, Toronto, Ontario.
USNM—U. S. National Museum, Washington, D. C.
YPM—Peabody Museum of Natural History, Yale University, New Haven, Conn.

TERMINOLOGY

The terminology used herein is the same as that employed in a recent paper (Whittington, 1950, p. 533) with two exceptions. I have used *pleural region* of the pygidium rather than pleural lobes or side lobes of Warburg (1925), and *interpleural grooves* or *ribs* rather than Warburg's interpleural or rib furrows. *Sutural ridge* denotes a narrow ridge upon (or beside) which either branch of the facial suture may run for all or part of its course on the exterior surface of the exoskeleton. Ross (1951) introduced the term *Bertillon pattern* (i.e. resembling that of a finger-print) for the pattern of curving, subconcentric, anastomosing raised lines occurring on the exterior surface of the axial or pleural regions of the exoskeleton of some trilobites.

SYSTEMATIC PALEONTOLOGY

Superfamily ILLAENICAE nom. nov.

Of the trilobite families appearing in the Ordovician, the Bathyuridae may be related most closely to the Illaenidae, Styginidae, and Scutellidae. These latter families have been regarded as related (Warburg, 1925, p. 78; Whittington, 1950, p. 547), and the Illaenidae appear in Lower Ordovician, the Styginidae and Scutellidae in Middle Ordovician, time. In common between the four families are the following characters; cephalon with forwardly expanding glabella, furrows faintly defined or lacking, eye lobes situated far back, eye surface with many

tiny facets, facial sutures opisthoparian, rostrum present, hypostome shield-shaped with crescentic posterior lobe of middle body; thorax of eight to ten segments; pygidium smaller than, or approaching size of, cephalon, with broad doublure, tendency for furrows on pleural regions to be radially arranged, and to a smoothing out of pleural regions; raised lines on external surface of exoskeleton, commonly a Bertillon pattern, tubercles much less common.

The Illaenidae, Styginidae, and Scutellidae were previously (Whittington, 1950, p. 547) referred to the Corynexochoidae. Recently Rasetti (1951, pp. 139–140) has discussed this superfamily and provisionally excluded from it all post-Cambrian families. I agree with this suggestion, for the distinguishing characters of the Corynexochoidae include (Rasetti, 1951, p. 140) the separation of the hypostome from the cranidium at the anterior margin by the hypostomal suture only. The rostrum is present in the four families considered here, and other characters that they have in common both unite them and distinguish them from the Corynexochoidae. Accordingly the new name is proposed, intended to include primarily Illaenidae, Scutellidae, Styginidae, and Bathyuridae.

Kobayashi (1935, p. 81) included the Lloydiidae and Leiostegiidae in his "Corynexochida." In the present paper *Lloydia* and *Leiostegium* and four other genera have been grouped tentatively (pending work in progress on the first two of these genera) in the family Leiostegiidae. This group may be related to the Bathyuridae, as discussed below, but this suggestion rests on a tenuous basis and may prove to be erroneous.

Swinnerton (1915, pp. 542–543) regarded the Illaenidae, Asaphidae, and Bathyuridae as related families. Warburg (1925, pp. 66–67, 78) doubted that the Asaphidae belonged with the other two, and they have the median cephalic suture and a quite different hypostome from that of the four families here included in the Illaenicae. I share the doubts expressed by Dr. Warburg, and do not place the Asaphidae in the Illaenicae.

Family BATHYURIDAE Walcott, 1886

Diagnosis.—Cephalon subsemicircular or nasute in outline, moderately to strongly convex, long, broad genal spines in some genera. Glabella expanding forwards or subparallel-sided, relatively long, furrows except occipital commonly absent, but up to three pairs of glabellar furrows may be faintly defined. Eye lobes large, situated far back and close to the glabella. Eye surface with many tiny facets. Facial sutures opisthoparian, anterior branches slightly to widely divergent forwards, rostral suture marginal. Connective suture where known runs in a curve convex inwards, so that the rostrum has a narrow "waist." Hypostome where known with short middle furrow and crescentic, convex, posterior lobe to middle body; anterior wings in two genera long and dorsally directed.

Thorax of nine segments (ten known only in *Goniotelus*). Pleurae commonly with deep, transverse furrow, terminations bluntly pointed, not extended into long spines. Pygidium somewhat, or much, smaller than the cephalon, five or six segments commonly indicated.

External surface of exoskeleton characteristically with raised lines in anastomosing Bertillon pattern, sometimes also, or instead, tubercles. A terminal pygidial spine may be present, in one genus an occipital and axial pygidial spine occur.

Geological range.—Middle Canadian to lower Trentonian.

Limits and inter-relationships.—Walcott (1886, p. 56) proposed this family to include *Bathyurus* and the Cambrian genera *Bathyuriscus* and *Asaphiscus*. The latter two have since been made types of distinct families. When Raymond (1913a, pp. 717–718) diagnosed the Bathyuridae he included three genera (other than *Bathyuriscus*). As used here, the family includes at least 15 genera, but fairly complete exoskeletons of only seven are known. The features common to the various genera are summarised in the diagnosis. It is generally recognised that the form of the hypostome is characteristic and distinctive of families of trilobites, and I believe that the nature of the sutures (if present) on the anterior cephalic border and doublure, and the form of the rostrum and its relation to the hypostome, may prove to be equally important in assessing family (and higher) relationships. These features are known in *Goniotelina* n. gen. and *Eleutherocentrus*, incompletely known in *Bathyurus*, *Raymondites* and *Goniotelus*. The

cephalic doublures and hypostomes of the remaining genera are unknown, with the exception of the cephalic doublures of *Bathyurellus* and *Uromystrum* n. gen. Examination of many specimens of *Bathyurellus nitidus* in the collections made by Dr. C. H. Kindle has failed to reveal any trace of sutures crossing the doublure. The known portion of the cephalic doublure of *Uromystrum validum* (Pl. 67, fig. 2) is likewise not crossed by sutures, and in both these genera the cephalic doublure may be entire. Lack of knowledge of the ventral exoskeleton is the main reason for my uncertainty as to the validity of the family diagnosis here given, the limits placed on the family, and relationships within it. However, groups of related genera may be recognised: 1) *Bathyurus* and *Raymondites* (Pl. 65), youngest in time of the family, occurring in Black River and Trenton strata; 2) in the high Canadian and early Middle Ordovician *Uromystrum* n. gen. and *Bathyurellus* (Pls. 67, 69); 3) in the middle and upper Canadian *Bolbocephalus*, *Rananasus* and *Petigurus* (Pl. 66); 4) in the upper Canadian are *Goniotelina* n. gen and *Bathyurina*, and related to them may be respectively the slightly younger genera *Goniotelus* and *Platyantyx* n. gen. (Pls. 68, 69); 5) *Peltabellia* n. gen., *Lutesvillia*, and possibly also *Jeffersonia*, from the middle and upper Canadian; 6) the early Middle Ordovician genus *Eleutherocentrus* (text-fig. 5), seemingly apart from the remainder. Of these groups, perhaps (3) and (5) stand near to each other, and from these Canadian forms those of group (1) may have been derived. Groups (2), (4), and (6) seem to stand apart from each other and the remainder, and certain of these genera may prove not to be bathyurids.

Distribution in space and time.—Throughout this paper the terms Lower Ordovician, Canadian, and Beekmantown have been used as synonyms, and Middle Ordovician to include Chazy, Black River, and Trenton. These latter are the present accepted divisions of the Middle Ordovician, but it does not seem to me certain that all strata in North America of post-Canadian and pre-Blackriveran age are necessarily equivalent to the Chazy of New York. Thus I have used the term "early Middle Ordovician" rather than "Chazyan," and in this span of time have placed, for example, Ross' zones L and M (1951, pp. 27, 31), the Table Head series of Western Newfoundland, and the fauna from limestone blocks of the Cow Head conglomerate (Schuchert and Dunbar, 1934, pp. 63–84).

A cursory examination of the literature indicates that few trilobites in the Old World or South America have been referred to the Bathyuridae. I have not seen any material from these regions, and the published descriptions of, for example, Reed, 1917, pp. 50–51, Pl. 8, figs. 7, 7a; Mansuy, 1920, pp. 14–15, Pl. 2, figs. 7a–k (this of the type of *Annamitella*, a genus referred to the Bathyuridae by Reed, 1936, p. 78); Sun, 1931, pp. 19–20, Pl. 3, fig. 1; Reed, 1936, pp. 78–81, Pl. 6, figs. 14–18; Chang, 1950, pp. 121–122, Pl. 2, figs. 5, 6; do not suggest to me that any one of them is certainly a bathyurid. Two records, that of *Petigurus* in northwest Scotland, and of *Bathyurellus* (?) in western Ireland, indicate the presence of bathyurids in the extreme west of Europe. Strand (1932, pp. 159–160, Pl. 27, figs. 4–8, text-fig. 16) identified a form from the Trondheim area, Norway, as "*Gonotelus*" *broeggeri*. The pygidium is like that of the widespread high Canadian form shown here on Pl. 68, fig. 31, as Ulrich recognized (in Strand, 1932, p. 163), but it might also be that of *Eleutherocentrus* or an asaphid like *Xenostegium*. The Bohemian Lower Ordovician genus *Pseudopetigurus* Prantl and Přibyl, 1949 (pp. 16–18, Pl. 3, figs. 2–4, text-figs. 7, 8) differs from *Petigurus* in several respects, as its authors note, and I do not think it is a bathyurid.

Bathyurids were first made known from Quebec and Newfoundland, and are now known in variety from the Lower Ordovician of eastern and northwestern Greenland, Ellesmereland, through Newfoundland and Quebec south and west to Pennsylvania, Missouri, Arkansas, Oklahoma, Texas, and, in the Cordillera, Alberta, Utah and Nevada. Early Middle Ordovician forms are known from both eastern and western areas, and Blackriveran and Trentonian bathyurids in the east and Mid-Continent. The present works adds to the evidence given by Poulsen (1927, 1937, 1946), Cullison (1944), and Ross (1951) of

the similarity between the middle and upper Canadian trilobite faunas of Greenland, Newfoundland, Quebec, Missouri, Arkansas, Oklahoma, Texas, and Cordilleran regions such as Utah.

Pattern of evolution.—In North America four genera of bathyurids appear in the middle Canadian, *Lutesvillia*, *Rananasus*, *Bolbocephalus*, and *Peltabellia* n. gen. In the upper Canadian the latter two of these are present, and six genera appear for the first time—*Bathyurina*, *Bathyurellus*, *Bolbocephalus*, *Goniotelina* n. gen., *Jeffersonia*, and *Petigurus*. In latest Canadian or early Middle Ordovician time *Uromystrum* n. gen. and *Eleutherocentrus* appear, together with *Goniotelus* and *Platyantyx* n. gen. from the St. Antoine boulder. In Black River strata *Bathyurus* and *Raymondites* are present, the latter persisting into early Trenton. If the range in time of each genus is plotted, a "burst" pattern of the type described by Cooper and Williams (1952, p. 330, text-fig. 3b) results. It is improbable that bathyurid trilobites are limited almost entirely to the North American continent, and this pattern is rather a "monographic burst" (to use the apt term coined by Cooper and Williams) than a portrayal of the real pattern of evolution in this family.

Mode of life.—Attention is drawn in the systematic section to the convex, high cephalon, with the bilaminar border concave upwards, and long, broad genal spines reaching back almost to the tip of the pygidium, in *Raymondites* and *Uromystrum* n. gen. These two trilobites are harpid in form (compare text-figs. 1a, 1b, with Richter, 1921, text-fig. 3a; Whittington, 1950a, text-figs. 2–9, pp. 25–26), as also are *Bathyurus* and *Platyantyx* n. gen. *Raymondites*, *Platyantyx* n. gen., *Eleutherocentrus*, *Goniotelus*, and *Goniotelina* n. gen., have the axial pygidial spine, and some species of *Raymondites* have the occipital spine. The broad cephalic border and the spines may be adaptations to a swimming or drifting, rather than crawling, mode of life. The lateral aspect of *Bathyurellus nitidus* (text-fig. 4) is suggestive of the same. Not all the genera of bathyurids, however, show such features.

Homeomorphy.—*Eleutherocentrus* was regarded originally by Clark as an asaphid.

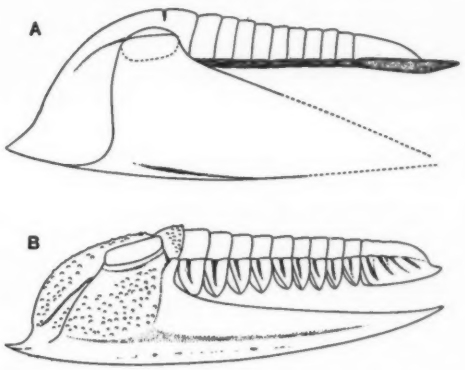


FIG. 1—*Uromystrum validum* (Billings). *A*, reconstruction of exoskeleton in lateral view, based on originals of pl. 67, figs. 1, 3, 10, approx. ×1½. *B*, *Raymondites longispinus* (Walcott). Reconstruction of exoskeleton in lateral view, based on holotype, approx. ×1¼.

The exoskeleton has a general resemblance to that of certain Lower Ordovician asaphids, but is distinguished by the cephalic sutures and type of hypostome.

Genus BATHYURUS Billings, 1859

Type species.—*Asaphus ? extans* Hall, 1847, designated Billings, 1859, p. 364.

BATHYURUS EXTANS (Hall), 1847
Plate 65, figures 1–9, 11–13, 17

Lectotype.—NYSM 4139, internal mold of a pygidium, original of Hall, 1847, Pl. 60, figs. 2a, 2b, from the Lowville limestone, Mohawk Valley, New York. The original of Hall's fig. 2c was not seen.

Description of lectotype.—Dimensions (approximately)—length (sag.) 17.5 mm., width 28 mm., height 9 mm. Outline subtriangular, moderately convex. Axis moderately convex (tr.), narrowing slightly (to two-thirds the width at the anterior margin) back to rounded tip. Lateral view (Pl. 65, fig. 3) shows profile of axis and steep slope at prominent termination. First three rings demarcated progressively less clearly posteriorly, and form less than half total length. Pleural regions gently convex and slope steeply to flat, less steeply-sloping border. No border furrow. Four pairs of pleural furrows, first straight, running out and slightly back, terminating against the facet. Second to fourth curved convexly forwards, increasingly strongly backwardly-directed

posteriorly. Anterior side of pleural furrow has the steeper slope, and the furrows extend on to inner part of border. First interpleural groove distinct, with anterior side vertical, and straight adjacent to, and on inner part of border.

The specimen is an internal mold, with a fracture running through the left pleural region at about half the width. The exoskeleton is adhering only in and beside the furrows, and shows the close-spaced, anastomosing ridges on the external surface.

Other material.—GSC, NYSM, USNM, ROMP, MCZ, from the following localities in the Lowville limestone: Watertown, including the City Quarry ½ mile north of Watertown, N. Y.; the quarry in the Lowville limestone on the north side of U. S. highway 4 and the N. Y. Central railroad, 1¾ miles west of Calcium (=Sanford Corners), Theresa quadrangle, N. Y.; Great Bend and Brownville, N. Y., and Kingston, Ontario. Specimens from the early Black River of Mechanicsville, Ottawa, Ontario also seem to belong here.

Description.—Cephalon with glabella expanding slightly forwards, occipital ring defined by broad occipital furrow, anterior lobe inflated and sloping vertically down to narrow (sag.) anterior border. Two pairs of glabellar furrows faintly indicated by broad, shallow depressions (Pl. 65, fig. 7). First commences opposite anterior part of eye lobe and runs inwards and backwards, is constricted at about one-third width of the glabella, then expands to terminate in a square impression just outside the median line. Second of uniform width, commencing just in front of eye lobe, less backwardly-directed, and reaching almost to midline. Eye lobe large, length (exs.) more than one-third that of glabella, situated close to both posterior border and glabella. Palpebral lobe with narrow rim, and sloping inwards. Opposite the anterior part of lobe the axial furrow almost dies out, so that palpebral lobe, narrow cheek area, and glabella are continuous at this point. Anterior branch of facial suture runs forwards to margin in a curve convex outwards, and presumably branches are united along margin. Posterior branch runs out and back in a sinuous curve, reaching margin at about half width (tr.). Narrow, flattened cephalic border, widest anterolaterally. Posterior border defined by a shallow furrow, widening outwards. Genal spine broad at base, extending back to a distance about equal to length (sag.) of cephalon, inner part vertical, outer flattened. Cephalic doublure and ventral sutures unknown.

Specimens from beds of Black River age at Mechanicsville, Ottawa, Ontario (Raymond and Narraway, 1910, p. 47, Pl. 15, fig. 8; this paper, Pl. 65, fig. 13) contain the hypostome of this species. In one (ROMP 18697), part of the hypostome, displaced in relation to the dorsal exoskeleton, is revealed, so that the association is fairly certain. Middle body moderately convex and narrows backwards, divided by short, deep furrows into a large anterior and small posterior lobe. Latter subcrescentic in outline, outer parts inflated so that they slope steeply to middle furrow but gently backwards. Anterior edge bent to slope steeply upwards, but no distinct border. Anterior wings long and slope upwards and outwards. Lateral border widest opposite middle furrow, inflated, and terminating at posterolateral corner, which is obliquely re-entrant. Posterior border has a narrow, convex rim, and is separated by a wide (sag. and exs.), shallow depression from posterior lobe of middle body.

External surface of glabella (Pl. 65, fig. 11) with close-spaced, anastomosing, raised lines, running in anterior half parallel to margins. On posterior half of glabella they run transversely in curves convex forwards. Scattered tubercles occur on median area in front of occipital ring, dying out forwards. Radially arranged lines occur on palpebral lobe, but elsewhere cheeks appear smooth. On hypostome similar lines run transversely in curves subparallel to margins.

Only one specimen (Pl. 65, figs. 6–8, 12) is relatively complete, showing nine segments in the thorax. Inner parts of pleurae horizontal, outer parts slope steeply and facetted. Pleural furrow straight and slightly backwardly directed. External surface of axis with close-spaced, anastomosing, raised lines running transversely in curves convex forwards, and present on rings and posterior part of articulating half-ring. Near posterior margin of ring a few tubercles may be present. On pleural regions the lines run longi-

tudinally, subparallel to margins, but as they reach each pleural furrow curve out and down.

Discussion.—The material here referred to *Bathyurus extans* is fragmentary, and it has not been possible to assemble it all in one place and compare and contrast the specimens directly. I have, therefore, drawn the limits of the species widely. The specimens from Watertown (Pl. 65, figs. 4, 5, 9, 11) and near Calcium, N. Y., appear identical with the lectotype, which itself is vaguely localized. Other specimens, e.g., those from Great Bend, N. Y. (Pl. 65, figs. 6–8, 12) have eyes rather more prominent, a stronger tuberculation of the glabella, and an apparently more rounded outline to the pygidium. Better material may reveal the systematic value of these variations. *B. extans* is characteristic of the Lowville limestone of New York, and of limestones of similar age in the Ottawa-St. Lawrence lowlands (cf. Young, 1943, p. 238; Wilson, 1947, pp. 16–17).

BATHYURUS ? ANGELINI Billings, 1859
Plate 65, figure 18

Bathyurus angelini BILLINGS, 1859, pp. 467–468, fig. 37.
Bathyurus angelini RAYMOND, 1905, pp. 335–337, Pl. 10, figs. 11, 12; RAYMOND, 1913, pp. 55–56, Pl. 7, fig. 5.

Material.—GSC 1084, 1084 a–c, 7829, 7815, 7815a, from the Beekmantown, Grenville, Argenteuil Co., Quebec.

Discussion.—The fragmentary material appears characteristic of the genus. The hypostome, occurring dissociated on a piece of rock with a pygidium, is like that of *B. extans* in general form.

BATHYURUS ? ACUTUS Raymond, 1913

Bathyurus acutus RAYMOND, 1913, pp. 56–57, Pl. 7, fig. 4.
Bathyurus acutus WILSON, 1947, p. 16, Pl. 2, figs. 1a, 1b, 2.

From the lower Pamelia, Westboro, west of Ottawa, Ontario. The hypostome is like that of *B. ? angelini*, and shows the large, dorsally deflected anterior wing, no complete specimen known, but if the association of cranidium and pygidium is correct, the terminal pygidial spine distinguishes this species.

BATHYURUS JOHNSTONI Raymond, 1913

Bathyurus johnstoni RAYMOND, 1913, p. 53, Pl. 7, figs. 2, 3.
Bathyurus johnstoni WILSON, 1947, p. 17, Pl. 2, figs. 12, 13.

From the Lowville beds of Cardin Township, Victoria Co., Ottawa. Types poorly preserved, cranidium exfoliated.

BATHYURUS MAGNUS Wilson, 1947

Bathyurus magnus WILSON, 1947, pp. 17–18, Pl. 2, fig. 14.

From the Lowville beds at City View, southwest of Ottawa. This specimen is poorly preserved, the pygidium similar both in size and appearance to one that I have here (Pl. 65, fig. 4) regarded as *B. extans*.

BATHYURUS SUPERBUS Raymond, 1910
Plate 69, figure 28

Bathyurus superbus RAYMOND, 1910, pp. 129–130, Pl. 2, figs. 1–3; RAYMOND, 1913, p. 54.
Bathyurus superbus WILSON, 1947, pp. 18–19, Pl. 2, figs. 10, 11.

Known from rocks of Pamelia age, at La Petite Chaudière, Mechanicsville, Ottawa, Ontario. The hypostome was described by Raymond, but no specimens have been found among the original material. The external surface with close-spaced, anastomosing raised lines, the arrangement on the thorax and pygidium like that of *B. extans*. The lines are present on both the glabella and genal spines, in curves convex forwards.

The relatively greater breadth, shorter genal spines, and broad, almost smooth pygidial border, distinguish this species from *B. extans*.

Distribution of Bathyurus.—The foregoing indicates that two species of *Bathyurus*, *B. extans* and *B. superbus*, are reasonably well known from the early Blackriveran of New York and Ontario. Bathyurids of *Bathyurus* type are present in the early Middle Ordovician of Virginia (e.g. Butts, 1941, Pl. 75, figs. 26–29; Pl. 94, figs. 27–29) and Pennsylvania (U. S. Nat. Mus. collections), and the Pogonip of Nevada (e.g., "*Bathyurus*" *pogonipensis* Hall and Whitfield, 1877, pp. 243–244, Pl. 1, figs. 33, 34). *Bathyurus* as known at present is confined to rocks of Blackriveran age, and the report of the species *B. ? angelini* from the Beekmantown suggests either that this species

belongs within another genus or that the dating of these rocks is incorrect.

Genus RAYMONDITES Sinclair, 1944

Type species.—by original designation, *Bathyurus ingalli* Raymond, 1913.

RAYMONDITES INGALLI (Raymond), 1913
Plate 69, figures 16–21

Bathyurus ingalli RAYMOND, 1913, pp. 57–58, pl. 7, fig. 7; RAYMOND, 1921, pp. 31–32, Pl. 9, figs. 3–5.
Bathyurus (*Raymondites*) *ingalli* SINCLAIR, 1944, p. 16, Pl. 1, figs. 9–11.
Bathyurus ingalli WILSON, 1947, pp. 19–20, Pl. 2, figs. 15–18.

Holotype.—GSC 4318, a crushed cranidium, original of Raymond, 1913, Pl. 7, fig. 7, from the base of the Trenton, near the liftlock 2 miles north of Kirkfield, Ontario.

Discussion.—The holotype and other previously known material of this species (dissociated pygidia and a free cheek) have been redescribed and figured recently by Wilson. Additional material only is here illustrated, including a damaged complete specimen. The latter confirms the association of cephalon and pygidium previously made, shows that the thorax consists of nine segments, and reveals the tubercles on the free cheek, axial rings, and inner part of the pleural regions of both thorax and pygidium.

Raymondites ingalli is distinguished from *Bathyurus extans* by the following: 1) While glabella expands slightly forwards in *Raymondites*, frontal lobe is more rounded in outline and less inflated than that of *Bathyurus*. Only first glabellar furrow, commencing opposite anterior end of eye lobe and curving inwards and backwards, is present in *Raymondites*. 2) Eye lobe is farther back in *Raymondites*, and palpebral rim and broad, shallow palpebral furrow strongly developed. 3) Anterior branch of facial suture is at first straight, directed forwards and slightly outwards, then curving in to margin across border. A wider (tr.) portion of fixed cheek than in *Bathyurus* is thus included in the cranidium, and, together with the long (sag.), concave preglabellar area, gives a characteristic form to *Raymondites* cranidium. 4) Long (sag.) anterior border in *Raymondites* probably means that anterolateral and lateral border is wide, wider than that of *Bathyurus*. 5) Long, stout occipital spine in *Raymondites ingalli*. 6) Pleural furrows in thorax and pygidium are deeper in *Raymondites*, trench-like, and stout axial pygidial spine in type species.

Sinclair (1944, p. 15) erected *Raymondites* as a subgenus of *Bathyurus*, and laid stress on the tubercles and spines as distinguishing the subgenus. I regard *Raymondites* as a separate genus, and place in it not only species which have small occipital spines, but one without such spines. I regard form of glabella, position of eye lobes, broad cephalic border and characteristic outline of cranidium, as more significant features than occipital spines in defining *Raymondites*. It is not significant for the genus whether or not the pygidia of all of the species here placed in *Raymondites* bear the axial spine.

It seems evident that *Raymondites*, the youngest bathyurid genus, is closely related to *Bathyurus*, and perhaps derived from it. I do not consider, however, that the presence of occipital and pygidial spines in some species of *Raymondites* is an example of the "tendency of survivors of a dying race to produce spines" (Sinclair, 1944, p. 15) but think it more probable that the spines, when present, had an adaptive value in the particular environment.

RAYMONDITES LONGISPINUS (Walcott), 1876
Plate 65, figures 10, 14–16, 19; plate 69, figure 29; text-figure 1b

Bathyurus longispinus WALCOTT, 1876, pp. 94–96.
Bathyurus longispinus RAYMOND & NARRAWAY, 1910, pp. 47–48, Pl. 16, figs. 12–14.

Holotype.—MCZ 3767, an incomplete specimen, "Black River Limestone," Buck's Quarry, Russia, Herkimer Co., N. Y. The exact horizon of Walcott's early collections from this locality is uncertain—it may be Black River or early Trenton.

Other material.—USNM, same locality as holotype; USNM from "Reynolds Mills," 4 miles west of Saratoga Springs, N. Y. Mr. D. W. Fisher informs me (personal communication) that this latter specimen can only be from Rowland's Mills (not "Reynolds Mills") and that he has referred the exposure there to the Larrabee member (Kay, 1937) of the Hull formation, Trenton group.

Discussion.—The new material illustrated here shows the cephalic doublure and course of the sutures. The former is broad, convex externally, extending in to inner margin of

borders and beneath genal spines. In front of glabella doublure is more strongly flexed, so that inner edge follows the curve of, and lies against inner side of, preglabellar furrow. Innermost part of doublure here slopes upwards and forwards (Pl. 65, fig. 19). Connective suture (Pl. 65, figs. 16, 19) commences at outer margin at a point almost below where dorsal suture reaches margin, curves in toward midline, turns abruptly before reaching midline, and runs upwards and outwards to cut inner margin of doublure beneath anterior end of axial furrow. Rostrum thus narrowest at midlength, and strongly bent. Hypostome unknown. Outer surface of exoskeleton tuberculate on glabella, cheeks inside borders, and inner distal part of genal spine. A pattern of close-spaced raised lines, anastomosing, everywhere present, in curves convex forward on glabella, parallel to margins on borders, and curving in across genal spine and then abruptly back at inner margin. Similar lines occur on thorax and pygidium, in curves convex forwards on axis, and on pleural regions of pygidium, transverse. Eye surface preserved in holotype (Pl. 69, fig. 29), gently convex transversely, and extending around lobe to face forwards, outwards and backwards. Large number of tiny facets, arranged alternately in vertical rows, gently convex on outer surface.

The cephalon of *Raymondites longispinus* is strongly vaulted, and the genal spines, composed of a steeply sloping inner part and a gently sloping outer part, are broad (tr.) proximally, and curve back to a sharp point, so that the tip lies on an exsagittal line just outside the eye lobe. If the thorax is extended back from the occipital ring in a plane parallel to that on which the outer edges of the cephalon rest, it will lie posteriorly increasingly higher above the inner edge of the genal spine (text-fig. 1b). Only the tips of the first one or two thoracic pleurae would lie beneath the inner margin of the genal spines, and Raymond and Narraway's drawing (Pl. 16, fig. 14) is inaccurate in this respect, and in making the genal spines too short. The mode of life of this species is discussed above.

Raymondites longispinus does not have a stout occipital spine or spines, though the tubercles on the posterior margin are elongated. None of the available specimens suggest the presence of a spine on the pygidium. The outline of the glabella and cranidium, position of the eye lobes, and presence of the broad, cephalic border, lead me to place this species in *Raymondites*.

Other Species of *Raymondites*

Described forms with one or more occipital spines include *Raymondites bandifer* Sinclair, 1944 (p. 17, Pl. 1, figs. 12–13; Wilson, 1947, p. 19, Pl. 2, fig. 7) from the Black River limestone of Ontario, *R. spiniger* (Hall, 1847; see Kay, 1937, Pl. 9) from the Rockland of New York and Ontario, and *R. trispinous* (Wilson, 1947, p. 21, Pl. 2, figs. 8, 9) from the Leray-Rockland beds of Ontario. A species with a short median and a pair of lateral spines on the occipital ring, and a spine on the pygidial axis, occurs in the Tyrone limestone, High Bridge, Kentucky (USNM 41932). *R. spiniger* was recognized by Foerste (1920, p. 222, Pl. 22, fig. 20) from the Plattin limestone of Missouri (USNM 78443) and a somewhat similar species occurs in Arkansas at about the same horizon (USNM collections), and in Illinois (USNM collections). Species of *Raymondites* of *longispinus* type, i.e., without occipital spines, are represented in the USNM collections from the "Upper Black River," Phelan and Jordan quarries, Dixon, Illinois (Pl. 69, fig. 22), a similar horizon at Mineral Point, Wisconsin, and the original of *R. schucherti* (Clarke, 1897, p. 724, figs. 41, 42), USNM 43052, from the "Trenton" (Platteville formation, McGregor member, according to Stauffer and Thiel, 1941, p. 244), of Minneapolis, Minn., is of this type also.

Raymondites thus appears to be widespread in the Mid-Continent and eastern North America, and occurs in rocks of Blackriveran and early Trentonian age.

Genus BOLBOCEPHALUS Whitfield, 1890

Type species.—by monotypy, *Bathyurus ? seelyi* Whitfield, 1886.

BOLBOCEPHALUS SEELYI (Whitfield), 1886
Plate 66, figures 1–10, 12–14, 17, 21, 22; text-figure 2

Lectotype.—selected by Whitfield, 1890, explanation of Pl. 3, AMNH 494a, original of Whitfield, 1886, Pl. 33, figs. 12, 13; 1890,

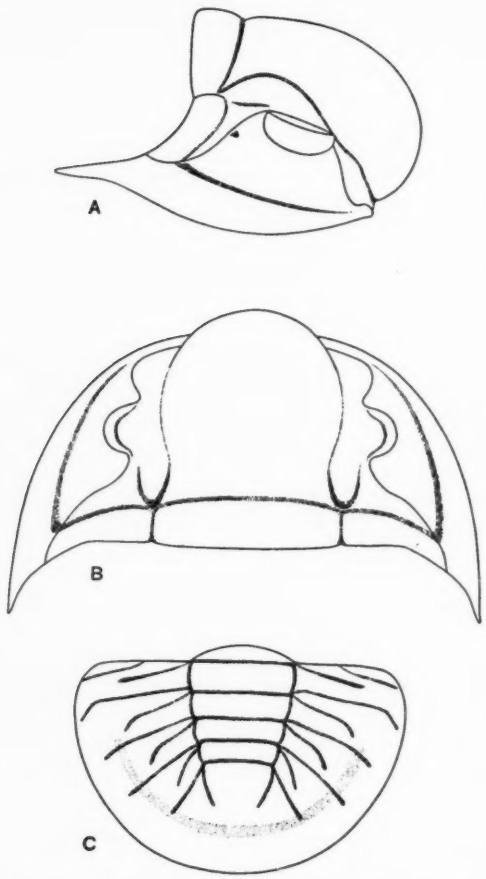


FIG. 2—*Bolbocephalus seelyi* (Whitfield). *A*, *B*, reconstructions of cephalon in right lateral and dorsal views, based on AMNH 494a–c, approx. ×1. *C*, reconstruction of pygidium, dorsal view, based on AMNH 494d–f, estimated size for association with cephalon shown in *B*.

Pl. 3, figs. 3, 4, internal mold of cranidium, from the Cassin formation, upper Canadian, Fort Cassin, Vermont.

Other material.—AMNH 494b–f, originals of Whitfield, 1886, Pl. 33, figs. 14–18, all from the same horizon and locality.

Description.—Dimensions of lectotype, AMNH 494a, in centimeters—length (sag.) of glabella, 3.75; width of occipital ring, 2.93; length (exs.) of palpebral lobe, 1.0; length (sag.) of occipital ring, 0.75. Glabella narrows in front of occipital ring, then expands until just in front of a point opposite anterior margin of eye lobes, where it reaches a width equal to that of occipital ring. Frontal lobe rounded in outline, moderately convex transversely, strongly convex longitudinally, so that it projects some distance in front of anterior border. Occipital ring moderately convex (tr.), posterior margin straight, occipital furrow shallow, running in a curve gently convex forwards. No glabellar furrows. Axial furrow deepest beside occipital ring, in front of here shallow, continuous with preglabellar furrow. Palpebral lobe situated opposite about midpoint of glabella, semicircular in outline, with a broad, flat rim defined by a shallow palpebral furrow. Fixed cheek inside palpebral lobe horizontal, gently convex, merging with inflated, inner posterior portion of the cheek. This latter defined by a faint furrow, or change in slope, which diverges from axial furrow at occipital furrow and runs forwards to join palpebral furrow. In front of palpebral lobe fixed cheek narrow, steeply sloping, and continuous with short (sag.), downward sloping preglabellar area. Anterior branch of facial suture at first straight, running forwards and outwards, then curving to run inwards subparallel to preglabellar furrow. Posterior branch runs out in a sigmoidal curve to reach border close to genal angle. Posterior border long (exs.), gently convex, border furrow shallow. Free cheek gently convex, slopes gently outwards adjacent to posterior border, more steeply anteriorly. Border narrowest anteriorly, widening towards genal angle; border furrow becomes shallower as it approaches this point. Genal spine short. External surface of glabella with fine, close-spaced anastomosing ridges subparallel to margins, and tiny pits between ridges. On border raised, continuous lines parallel to margin. Hypostome and thorax unknown.

Whitfield (1890, pp. 36–38, Pl. 2, figs. 6–8, Pl. 3, figs. 7, 8) found two types of pygidia associated with *Bolbocephalus* cranidia. He regarded one as most likely belonging with *B. seelyi*, and described the second as *B.? truncatus*. The same two types of pygidia occur in the USNM collections. Whitfield's types that he referred to *B. seelyi* are refigured here and may be described as follows:

Outline subsemicircular, gently convex, width of AMNH 494d approximately 4 cms. Axis moderately convex (tr. and sag.), with

four rings defined by straight furrows. Termination longer than any of rings, and bluntly rounded. Pleural regions gently convex, and slope gently outwards, with a less steeply sloping border. Four pairs of deep, narrow, interpleural grooves, the first three extending on to border, and first curving back and reaching the margin. Four pairs of pleural furrows with a sigmoidal course, reaching out to border furrow. Doublure as wide as border, flat, and outwardly sloping. One specimen (Pl. 66, fig. 22) shows external surface of exoskeleton with raised, anastomosing lines sub-parallel to margins on border and outer part of pleural regions. Tiny pits appear between lines behind axis. On an internal mold low, close-spaced tubercles occur on axis and pleural regions.

An example of the pygidium *Bolbocephalus ? truncatus* Whitfield, 1890, is figured here (Pl. 69, figs. 23, 24), and referred to *Strigigenalis cassinensis*, n. gen., n. sp. E. O. Ulrich's manuscript notes in the U. S. National Museum show that he regarded the *truncatus*-type pygidium as that of *B. seelyi*, and that described above as representing a different genus. Cullison (1944, pp. 78–79, Pl. 35, figs. 30, 31) followed Ulrich in associating a *truncatus*-type pygidium with the *Bolbocephalus* cranidium. The external surface is not preserved in the *truncatus*-type pygidia that I have seen, but the raised lines on the first type of pygidium are like those on the cephalon of *B. seelyi*. Whitfield was probably correct in his association of cephalon and pygidium, but more evidence is needed before one can be certain.

Discussion.—In addition to Whitfield's original material, a small cranidium from the USNM collection is figured (Pl. 66, figs. 7, 8, 12). A single cranidium from the same locality (Pl. 66, figs. 11, 15, 16) has the frontal part of the glabella inflated into a rounded, upward and forwardly pointing peak. The general form of the remainder of the cranidium, however, including the inflation of the inner, posterior part of the cheek, and the ornament, is like that of *Bolbocephalus seelyi*. This unusual cranidium may be a variety of *B. seelyi*, but more probably is a different species or even genus.

The cephala of *Petigurus* and *Bolbocephalus* are similar (see Pl. 66 and compare text-figs. 2 and 3). *Bolbocephalus* is distinguished by the narrowing of the glabella in front of the occipital ring, and the lack of tubercular ornament. The inflated inner posterior part of the fixed cheek in *B. seelyi* is peculiar to that species, and not shown so markedly by other known species.

Other species of *Bolbocephalus*

Bolbocephalus glaber and *B. angustisulcatus* were described by Poulsen (1927, pp. 304–305, Pl. 20, figs. 10, 26, 27) from the upper Canadian of northwestern Greenland, and *B. groenlandicus* Poulsen (1937, pp. 48–49, Pl. 5, figs. 9–13) is from the upper Canadian of eastern Greenland. The cranidium of *B. groenlandicus* is characteristic of the genus. The pygidia referred to this species, and to *B. glaber*, are of *truncatus* type, while the holotype of *B. angustisulcatus* is a pygidium of the type referred to *B. seelyi* by Whitfield.

Cullison (1944, pp. 77–79, Pl. 34, figs. 28–29, Pl. 35, figs. 27–31) described two species of *Bolbocephalus* from the middle and upper Canadian of Missouri. The cranidia appear typical, but the pygidia are rather of the *truncatus* type. Cloud and Barnes (1948, Pl. 42, figs. 24, 25) figured pygidia of the same general type from the Honeycut formation, middle Canadian, central Texas. A cranidium from the upper Canadian of Utah was recently figured by Hintze (1953, pp. 143–144, Pl. 9, fig. 17).

Bolbocephalus occurs also in the Beekmantown of Phillipsburg, Quebec, and the associated pygidium is of the type described by Whitfield as *B. seelyi*. The genus is of middle and upper Canadian age, and known from Greenland, Quebec, Vermont, Missouri, and Utah.

Genus Rananasus Cullison, 1944

Type species.—by original designation, *Rananasus conicus* Cullison, 1944 (p. 82, Pl. 34, figs. 36–40), from the Rich Fountain formation, middle Canadian, Missouri, and the Honeycut formation, Ellenburger group, Central Texas (Cloud and Barnes, 1948, Pl. 42, figs. 10–15).

Discussion.—Only dissociated cranidia and pygidia are known. The general form of the glabella, including the reduction in width immediately in front of the occipital ring, and the expansion in front of this, and

the lack of furrows, recall *Bolbocephalus* and suggest a relationship.

Genus PETIGURUS Raymond, 1913

Type species.—by original designation, *Bathyurus nero* Billings, 1865.

PETIGURUS NERO (Billings), 1865
Plate 66, figures 18–20, 23–25; text-figure 3

Lectotype (here selected).—GSC 750, internal mold of glabella, original of Billings 1865, p. 260, figs. 243a, 243b, from Division H, St. George series, Table Head, western Newfoundland.

Other material.—GSC 637, 637a, 637b, Division G, St. George series, Port aux Choix, western Newfoundland; GSC 8444, incomplete cranidium, free cheek, three pygidia, all exfoliated, Divisions F, G, H, St. George series, Keppel Island, western Newfoundland; ROMP 18708, exfoliated cranidium and pygidium, Lower Ordovician of Newfoundland.

Description.—Glabella straight-sided, bluntly rounded in front, expanding slightly forwards, frontal lobe inflated and overhanging short (sag.) anterior border. Occipital furrow straight, broad and deep. Axial and preglabellar furrows continuous, moderately deep. Glabellar furrows absent. Cheek convex, steeply sloping anterolaterally, with narrow border. Eye lobe large, situated opposite a point about half glabellar length. Anterior branch of suture runs forwards and slightly outwards from eye lobe, then curves in towards border. Posterior border furrow broad and deep, border convex. Coarse tubercles on external surface of glabella and cheeks. Remainder of cephalon, and thorax, unknown.

Pygidium (assigned here by Billings) subtrapezoidal in outline, moderately convex. Axis defined by deep furrows, gently convex and standing only slightly above pleural regions, consisting of four rings and short termination. Four pairs of straight, deep, and broad pleural furrows, progressively more strongly backwardly inclined, and each furrow diagonal, so that it abuts against interpleural ridge at border. Latter narrow, convex, outwardly sloping, widest behind axis. Coarse tubercles on axial rings and raised parts of pleural regions.

Discussion.—The similarity between the cephala of *Petigurus* and *Bolbocephalus* has been referred to. The straight-sided, less inflated glabella, the deeper, broader cephalic furrows, and the tuberculation distinguish *Petigurus*.

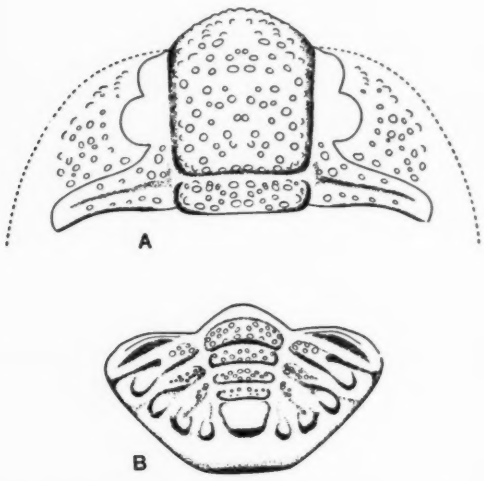


FIG. 3—*Petigurus nero* (Billings). *A*, partial reconstruction of cephalon, dorsal view, based on GSC 637a, 750, 8444d, approx. ×1½. *B*, pygidium, dorsal view, based on GSC 637, approx. ×1½.

Other Species of *Petigurus*

Petigurus cybele (Billings, 1859, p. 366, fig. 12d, non 12c); Twenhofel, 1938, p. 71, Pl. 10, figs. 5, 6. Romaine formation, upper Canadian, Mingan Islands, Quebec. Types, GSC 518, 518a, incomplete cranidia. GSC 518a shows the inflated palpebral lobes with a broad rim and rim furrow.

Petigurus groenlandicus Poulsen, 1937, pp. 49–51, Pl. 6, figs. 1–13, from the Cape Weber formation, upper Canadian, East Greenland. *Petigurus* sp. has also been recorded from Ellesmere Land (Poulsen, 1946, pp. 327–328, Pl. 23, figs. 2–3), from the Lower Ordovician of Scotland (Stubblefield, 1939, p. 58), and is present in the USNM collections from the upper Canadian of Fort Cassin, Vermont. Bradley's (1925, pp. 5–6, Pl. 1, fig. 3) "*P.*" *subrectus* is here referred to *Goniotelina* n. gen.

Genus UROMYSTRUM Whittington, n. gen.

Type species.—*Bathyurellus validus* Billings, 1865.

UROMYSTRUM VALIDUM (Billings), 1865
Plate 67, figures 1–5; text-figure 1a

Bathyurellus validus BILLINGS, 1865, p. 268, fig. 252.
Bathyurellus validus RAYMOND, 1925, p. 72.
Bathyurellus fraternus RAYMOND, 1925, pp. 73–74, Pl. 3, fig. 19 (?non *B. fraternus* Billings, 1865, pp. 267–268, figs. 251a, 251b).

Lectotype (here selected).—GSC 642, incomplete exfoliated cephalon, from Division L, Table Head series, Point Riche, western Newfoundland. The pygidium, original of Billings fig. 252, has not been found in the GSC collections.

Description of lectotype.—Cephalon subsemicircular in outline, length (sag.) slightly more than half width at posterior margin, convex, height half width. Glabella gently convex (tr. and sag.), narrowest (tr.) at base and expanding slightly forwards, and reaching to about three-quarters length (sag.) of cephalon; occipital furrow shallow, glabellar furrows absent; axial furrows deepest beside occipital ring, shallowing forwards, preglabellar furrow faintly defining bluntly pointed anterior lobe. Cheeks and preglabellar area continuous, steeply sloping anteriorly and anterolaterally, becoming vertical and overhanging margin at base of genal spines. Border, concave upwards, is present anteriorly, narrowing laterally, not defined by a furrow, but by the change in slope. Eye lobe long, almost half length of glabella, situated far back, so that posterior margin is behind a transverse line passing through occipital furrow, and close to glabella. Palpebral lobe convex (tr. and exs.), merging with convex inner cheek area to form an ovate, swollen region inside eye surface, apparently no palpebral rim. Anterior branches of suture diverge outwards and downwards at about 60° to sagittal line, then curve across concave border to meet margin at a point on an exsagittal line outside eye lobe. Presumably branches united along margin. If a posterior border is present it must be narrow (exs.), and border furrow, if present, does not extend far out. Genal spines broad (tr.) at base, at least two-thirds width of cheek measuring over surface, and tapering back, extend to a length (exs.) about equal to that of cephalon (sag.). Internal mold of doublure of anterior and left anterolateral portions of cephalon partially revealed in the lectotype (Pl. 67, fig. 2). No median suture, and if connective sutures are present they are far apart. Unfortunately the edge of the specimen is broken near where the left branch of dorsal suture reaches margin, and the rest of doublure concealed.

Internal mold of left cheek shows a pattern of close-spaced, shallow pits. On outer surface of left genal spine tiny pits widely scattered, and raised lines curve back near margins. On doublure well spaced raised lines parallel to margins.

Description of MCZ 1643.—This specimen (Pl. 67, figs. 3, 10) is the original of *Bathyurellus fraternus* of Raymond, 1925, Pl. 3, fig. 19, and was collected by A. Hyatt from the west side of Gargamelle Cove, western Newfoundland. Raymond (1925, p. 74) states that the specimen came from "near the base of the Chazy," and it is clear from Schuchert and Dunbar's account (1934, pp. 25, 55, 65) that this rather vague locality may well be in the lower part of the Table Head series, and thus about the same horizon as that which yielded the lectotype of *U. validum*. Billings (1865, p. 268) and Raymond were aware that *U. validum* and "*B.*" *fraternus* were similar. I consider that Hyatt's specimen belongs in *U. validum*, and that the type of "*B.*" *fraternus* (GSC 643, from division P, Cow Head conglomerate, western Newfoundland) may possibly represent the same species.

Cephalon incomplete, poorly preserved, and shows no additional features, except that the anterior doublure is recurved so that the innermost part points upwards and forwards (Pl. 67, fig. 3).

Thorax of nine segments, length two-thirds maximum width. Axis little more than one-third total width, moderately convex, tapering back and reduced in height. Articulating furrow shallow, half-ring reaching forwards to two-thirds length. Pleurae extend out horizontally, outer part flexed up gently. First three have outer, anterior corner cut off diagonally to form a large facet, the remaining end bluntly with a much smaller facet, outer margin gently curved and slightly thickened. A faint, broad transverse depression, dying out toward upturned extremity, constitutes the pleural furrow.

Pygidium semicircular in outline. Axis ex-

tends just over half length, low, and bluntly rounded. Four rings faintly marked on external surface, clearly on internal mold. Pleural regions concave, maximum depth midway between axis and margin. Only the inner, anterior part, adjacent to inner part of ninth thoracic pleura, horizontal. Broad depressions indicate first two pleural furrows. Broad doublure (Pl. 67, fig. 5) reaching to inner part of pleural regions and tip of axis, inner edge bent steeply up.

External surface of thorax and pygidium smooth, apart from raised lines that run diagonally across anterolateral portions of thoracic pleurae, and on pygidial doublure parallel to the margins.

The lateral aspect of *Uromystrum validum* is reconstructed in text-fig. 1a. It appears that the genal spines reached back almost to the tip of the pygidium, and the height of the cephalon means that, when the thorax and pygidium were stretched out, they were high above the lateral cephalic margins. The mode of life of this species is discussed above.

Other Species of *Uromystrum*

The following species appear to belong in this genus, for they have the same type of semicircular, deeply concave pygidium, only faintly furrowed on the external surface:

U. brevispinum (Raymond, 1905, pp. 337–338, Pl. 10, figs. 13–15; 1910, pp. 218–219, Pl. 32, figs. 13–15; 1925, p. 75) from the upper Chazy, in a pasture 3 miles southeast of Chazy, N. Y., near Little Monty Bay.

U. minor (Raymond, 1905, pp. 338–339, Pl. 10, fig. 16; 1910, p. 219, Pl. 32, fig. 16), from the middle Chazy of Crown Point and Valcour Island.

U. affinis (Poulsen, 1937, p. 55, Pl. 7, figs. 6, 7) from the high Lower Ordovician of East Greenland. Poulsen pointed out the peculiar characters of the pygidium of this species, and its probable relationship to *U. validum* and *U. minor*.

Genus BATHYURELLUS Billings, 1865

Type species.—*Bathyurellus abruptus* Billings, 1865, designated Raymond 1905, p. 337.

BATHYURELLUS ABRUPTUS Billings, 1865
Plate 69, figures 26, 27

Lectotype (here selected).—GSC 648, an incomplete, partly exfoliated pygidium, from Divisions F, G, H, St. George series, Port aux Choix, Newfoundland.

Other material.—GSC 648a, 648b, partly exfoliated pygidia, and with the lectotype forming the originals of Billings' fig. 250, p. 263, same locality and horizon. The specimen of the cranidium on which fig. 247, p. 263, is based, is missing.

Description.—Length about equal to width, posterolateral corners rounded, height about half width. Axis tapers rapidly, reaching to slightly less than half length, convex, defined by deep furrows which shallow around tip. Inner parts of pleural regions convex, anterolateral parts concave, posterior parts sloping gently back and more steeply laterally. Facet large, almost vertical, and short, deep first pleural furrow ends against it. First interpleural groove runs out and back to inner margin of facet, and then curves to follow this inner margin and die out. The low ridge that lies in front of this groove and extends out along posterior margin of facet is the "obscure rounded fold" of Billings, 1865, p. 264. Second pleural furrow faint. Outer surface of exoskeleton preserved in anterior half of specimen. Axis with anastomosing raised lines, running in curves convex forwards, the convexity greatest anteriorly. On median part of axis there are minute pits between the lines. On left pleural region similar lines run forwards and outwards on inner part, turning to run outward and back on fold bounding smooth facet.

Discussion.—The lectotype selection made above means that the diplotype of *Bathyurellus* is a pygidium, and until a complete specimen of *B. abruptus* is described the characters of the remainder of the exoskeleton must remain in doubt. The type of cranidium associated with the *B. abruptus* pygidium by Billings (1865, p. 263, fig. 247) is also present in Dr. C. H. Kindle's collection from Port aux Choix and the association seems probable. Further, *B. nitidus* (see below) is represented by many complete specimens. The pygidium, though different in outline and convexity, is of *B. abruptus* type and the cephalon is also of the type attributed to *B. abruptus*. Acting on the assumption that *B. nitidus* and *B. abruptus* are congeneric, at least five more species may be placed in *Bathyurellus*, as indicated below.

BATHYURELLUS NITIDUS Billings, 1865
Plate 67, figures 9, 13–15; text-figure 4

Lectotype (here selected).—GSC 645e, 645b, counterparts of the original of Billings, 1865, p. 265, fig. 249, from Division P, Cow Head conglomerate, Cow Head, western Newfoundland.

Other material.—GSC 645, 645a, c, d, f, g, including incomplete cephala, same horizon and locality; many complete specimens and cephala in collections made by Dr. C. H. Kindle, from the Cow Head conglomerate, Lower Head, western Newfoundland.

Discussion.—Cephalon with glabella narrowing forwards, defined by deep furrows, anterior margin acutely rounded. In addition to these features which distinguish the cephalon from that of *Uromystrum*, the eye lobe is relatively farther forwards, the anterior branches of the sutures less divergent, the height relatively less (compare text-figs. 1a and 4), the genal spines smaller, and the preglabellar area less steeply inclined. As in *Uromystrum* the cephalic doublure is peripherally flat, the inner part bent steeply up. Sutures crossing doublure not detected. Thorax of nine segments, differing from that of *Uromystrum* in that pleural furrows are deeper and outer parts of pleurae bent down and facetted, fulcrum at about half width. Pygidium subsemicircular in outline, axis extending about half length, first ring distinct, second and third fainter. Pleural regions divided into a smaller, convex inner part, and a broader, concave outer part which extends behind axis. Line of division between these two parts probably coincides with inner edge of doublure. Three pleural furrows present on inner part of pleural regions, first much the deepest, and they do not extend on to the outer part. Only first interpleural groove faintly indicated in this area, but three pairs of interpleural grooves, separated by gently convex ribs, on inner part of concave region, which disappear outwards. First groove much the strongest.

In text-fig. 4 the lateral view of *Bathyurellus nitidus* is drawn with the lateral margin of the cephalon inclined downwards and forwards, since this is the position it assumes when the plane passing through the posterior margin of the occipital ring is parallel to the corresponding planes of the axial rings of the thorax (cf. Pl. 67, fig. 9). Specimens in the Kindle collection show that the lateral margin of the cephalon may be horizontal (as in the dorsal view, text-fig. 4) and inclined upwards and forwards. In this latter position the first three segments of the thorax are flexed sharply upwards.

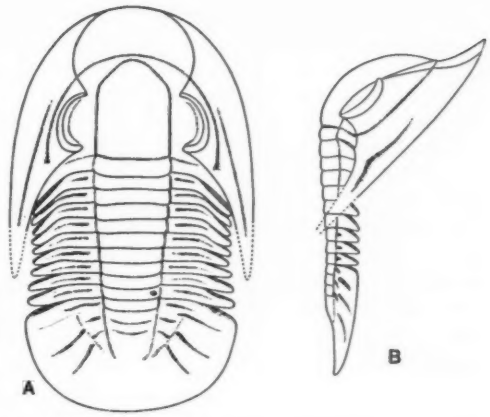


FIG. 4—*Bathyurellus nitidus* (Billings). *A*, dorsal view, *B*, right lateral view, based on GSC 645b, c, e, approx. ×4.

Other Species of *Bathyurellus*

B. marginiatus Billings, 1865, pp. 264–265, fig. 248, from Divisions F, G, H, St. George series, Keppel Island, western Newfoundland. Lectotype (here selected), GSC 646, an incomplete cranidium, original of Billings' fig. 248. Other material: GSC 646a, an incomplete cranidium, partially exfoliated, same locality; GSC 647, a pygidium, original of Billings' fig. 249, p. 263, from Port aux Choix, Newfoundland.

B. formosus (Billings, 1865, pp. 266–267, fig. 250, p. 265), from Division P, Cow Head conglomerate, Cow Head, Newfoundland. GSC 644, an incomplete cephalon with six thoracic segments, 644a an incomplete cranidium.

B. expansus (Billings, 1865, pp. 318–320 figs. 306a, 306b), from Stanbridge range 6, lot 20, Missisquoi Co., Quebec. GSC 844, 844a–d, 844a original of fig. 306a, 844c original of fig. 306b. In the latter the second and third pleural furrows and interpleural grooves are faint, the fourth extremely faint.

B. ? flabellus (Bradley, 1925, p. 5, Pl. 1, fig. 7), based upon a poorly preserved pygidium from the upper Beekmantown of Phillipsburg, Quebec, is perhaps congeneric.

Reed (1945, p. 60) regarded his species *B. glensaulensis* (Reed, 1910, pp. 274–275, Pl. 21, figs. 1a–3b), from the Lower Ordovician of Ireland, as close to *B. expansus* Billings.

B. teicherti Poulsen (1937, pp. 53–55, Pl. 7, figs. 2–5; 1946, p. 325, Pl. 22, figs. 10–13), from the high Lower Ordovician of East Greenland and Ellesmere Land. The pygidium of this species is like that of the type, though the length is relatively less.

B. pogonipensis Hintze (1953, pp. 138–140, Pl. 10, figs. 11–19), from the early Middle Ordovician of Utah.

Genus JEFFERSONIA Ulrich, in Poulsen 1927

Type species.—by monotypy, *Jeffersonia exterminata* Poulsen, 1927, pp. 303–304, Pl. 20, fig. 28, from the upper Canadian Nunatami formation of northwest Greenland.

Discussion.—The type species is only known from two pygidia, and I suggest, therefore, that until more material is described, the name *Jeffersonia* be used solely for the type species. Cullison (1944, pp. 70–71) recognized the difficulties arising from the unsatisfactory nature of the type, but chose to use the name *Jeffersonia*, in the sense apparently originally intended by Ulrich, for a number of new species. None of these species is represented by a complete exoskeleton, the cranidia and pygidia included showing a variety of form, and I do not think that the nine species of "*Jeffersonia*" described by Cullison are congeneric. Ross (1951, pp. 76–77, Pl. 17, figs. 7, 8, 12, 13, 16–22) has described the species "*J.*" *peltabella* from zone G of the Garden City formation, and pointed out that it is congeneric with "*J.*" *missouriensis* Cullison (1944, pp. 71–72, Pl. 34. figs. 10–13, non figs. 14, 15, ? 16; Ross, 1951, Pl. 15, fig. 15), "*Bathyurellus*" *permarginatus* (Cullison, 1944, p. 70, Pl. 34, figs. 23, 24), both from the Rich Fountain formation, and "*Bathyurus*" *amplimarginatus* (Billings, 1859, p. 365, figs. 12a, 12b; 1865, p. 353, fig. 341a; Twenhofel, 1938, pp. 71–72, Pl. 10, fig. 13) from the Romaine formation, upper Canadian, Mingan Islands, Quebec. I propose that these four species should be regarded as representing a new genus, as follows:

Genus PELTABELLIA Whittington, n. gen.

Type species.—*Jeffersonia peltabella* Ross, 1951, pp. 76–77, Pl. 17, figures 7, 8, 12, 13, 16–22, from zone G of the Garden City formation, Canadian of northeastern Utah.

The material from western Utah recently described by Hintze (1953, pp. 174–176, Pl. 9, figs. 8, 11, 12; Pl. 10, figs. 7–10) probably represents species of *Peltabellia*.

Genus LUTESVILLIA Cullison, 1944

Type species.—by original designation, *Lutesvillia bispinosa* Cullison, 1944 (pp. 79–80, Pl. 35, figs. 1–6), from the Theodosia formation, middle Canadian, Missouri.

Discussion.—The cephalon and pygidium are of bathyurid type, the pygidium being distinguished by the pair of marginal spines. Cullison commented on the similarity between *Lutesvillia* and species here referred to *Peltabellia*.

Genus GONIOTELUS Ulrich, 1927

Goniurus RAYMOND, 1913, non *Goniurus* Hübner, 1819, p. 104.
Gonotelus ULRICH, in Strand, 1932, p. 159.
Acidiphorus RAYMOND, 1925, p. 131, may also be a synonym (see below).

Type species.—*Bathyurus perspicator* Billings, 1865, by original designation of Raymond, 1913, p. 65.

GONIOTELUS PERSPICATOR (Billings), 1865
Plate 68, figures 1–10

Bathyurus perspicator BILLINGS, 1865, pp. 205–206, fig. 191.
Goniurus perspicator RAYMOND, 1913, p. 65, Pl. 7, fig. 10.
Goniotelus perspicator ROSS, 1951, p. 69.

Holotype.—GSC 847, a partially exfoliated cephalon, original of Billings' figure 191, from boulder at St. Antoine de Tilly, Lotbinière Co., Quebec (see Appendix on age of this boulder).

Other material.—GSC 7836, original of Raymond, 1913, pl. 7, figure 10; GSC 403, several incomplete cephala and pygidia, including the originals of Pl. 68, figures 3, 4, 6–10; all from the same boulder as the holotype.

Description.—Dimensions in millimeters of holotype and original of Pl. 68, figures 3, 9 respectively: Length of cephalon (sag.), 7.0, 3.4; length of cephalon (exs.), —,

4.9; width of cephalon at genal angles, —, approx. 7.0; height of cephalon, —, 2.6; length of glabella, 6.7, 3.3; maximum width of glabella, 4.9, 2.7; length of occipital ring (sag.), 1.3, 0.8; length of eye lobe (exs.), 3.1, 1.5.

Glabella subrectangular in outline, anterior lobe bluntly rounded, maximum width just in front of half length, gently convex transversely, moderately convex longitudinally, anterior lobe overhanging preglabellar furrow. Occipital ring longest in midline, defined by narrow occipital furrow. In front of occipital ring glabella narrows slightly, then expands to maximum width. Two pairs of glabellar furrows, situated just in front of, and just behind, widest part of glabella, commencing at axial furrow and curving inwards and backwards, extending in to about one-third glabellar width. On external surface these furrows faint, smooth areas (Pl. 68, fig. 3), on internal surface more distinct depressions are evident, as internal molds show (Pl. 68, fig. 1). Axial furrows shallow, continuous with deeper preglabellar furrow. Eye lobe long, gently curved, inner anterior margin adjacent to axial furrow, inner posterior margin a short distance outside this furrow. Palpebral lobe flat, with narrow, convex rim. Eye surface with facets arranged as shown in Pl. 68, figure 4. Behind eye the fixed cheek slopes steeply to posterior border furrow. Outside eye the cheek gently convex, sloping most steeply anterolaterally, and continuous with gently convex preglabellar field, which shortens towards midline and is almost absent there. Cephalic border narrow, convex, with narrow border furrow anteriorly, becoming broader anterolaterally and laterally, and then narrower again where it extends to tip of genal spine. Posterior border convex, posterior border furrow broad and deep, dying out at base of genal spine. A shallow, curving furrow connects posterior border and lateral border furrows. Genal spine broad at base, tapering rapidly. Posterior branch of facial suture curves out from eye lobe, crosses posterior border furrow at a low angle, and then turns to cut posterior border a short distance inside base of genal spine. Anterior branch of suture runs forward in a curve to border, then diagonally in across border and on to outer edge of the downward and forward facing doublure, to meet the rostral suture at an obtuse angle (Pl. 68, fig. 10). Rostrum a convex plate, width at anterior margin about one-third maximum glabellar width, projecting below adjacent part of doublure and narrowing backwards. Remainder of cephalic doublure, and hypostome, unknown.

External surface of cephalon with raised anastomosing lines on glabella, running transversely in curves convex forwards. Similar lines less prominent on cheeks inside border, which are tuberculate. Cephalic borders and genal spine with raised lines parallel to margins.

Thorax unknown.

Pygidium triangular in outline, length (sag., excluding spine) less than width, and about equal to height. Axis moderately convex, defined by shallow furrows which die out at base of spine. On external surface the articulating, but no ring, furrows present. Internal molds indicate position of first three rings. Pleural regions slope steeply, inner part convex, outer concave. no border defined. Axis and pleural regions extended posteriorly in short, horizontal spine. First pleural furrow broad and shallow, first interpleural rib present, and facet large. Doublure broad, convex on outer surface, extending in to inner part of pleural regions.

Discussion.—A second species of *Goniotelus*, from the Cow Head conglomerate, Lower Head, Newfoundland, is represented in the collections made by Dr. C. H. Kindle. The one complete specimen has ten segments in the thorax, and a pygidium like that of *G. perspicator*, confirming the association made for the type species. Raymond (1913, p. 66) placed two additional species in *Goniotelus*, and Cullison (1944, pp. 83–84) referred two new species here also. I do not consider that any of these four species should be referred to *Goniotelus*, and they are further discussed below. The relationship between *Goniotelus* and *Goniotelina* is discussed under the latter genus.

Genus GONIOTELINA Whittington and Ross, n. gen.

Acidiphorus RAYMOND, 1913, may be a synonym (see below).

Bathyurina POULSEN, 1937, may be a synonym (see below).

Type species.—*Eleutherocentrus williamsi* Ross, 1951.

Diagnosis.—This genus includes *Goniotelus*-like forms possessing parallel sided glabellae and large, distinctly rimmed, posteriorly located, sub-semicircular palpebral lobes. Cephalon with subtubular border. Genal spines, when present, vary in length from mere nubs to long, slim, curving spines, or may be extremely stout. Glabella possesses only an occipital furrow. Anteriorly it is separated from border by a short (sag. or exs.) preglabellar field. Anterior branches of facial sutures are essentially same as those of *Goniotelus*, and posterior branches run lateral nearly parallel with, and close to, posterior border furrow; as a result the posterolateral extensions of the cranidium (posterolateral limbs of some authors) are exceedingly slender (exs.). Rostrum present; anterior surface rounded or "prow"-shaped, while its posterodorsal extension as part of the doublure is bluntly spatulate and concave on the posterior side.

Hypostome characterized by strong convexity of middle body, a tubular border without spines and other protuberances on ventral or lateral surfaces, and extremely long and slender anterior wings directed dorsally.

Panderian organ represented by a quadrangular notch within the genal angle on doublure of free cheek, and probably by a similar notch in doublure of each thoracic pleura, one edge of which has the added function of limiting enrollment.

Pygidium with strongly convex axis of five rings, of which last is bluntly rounded and longer than the others. Pleural regions exhibit three pleural furrows in most species; these furrows do not attain the margin, but are transected by a border furrow varying in development between species. Terminal spine may be present; it originates immediately to rear of axis, appearing to stem from axis in some species and from border in others.

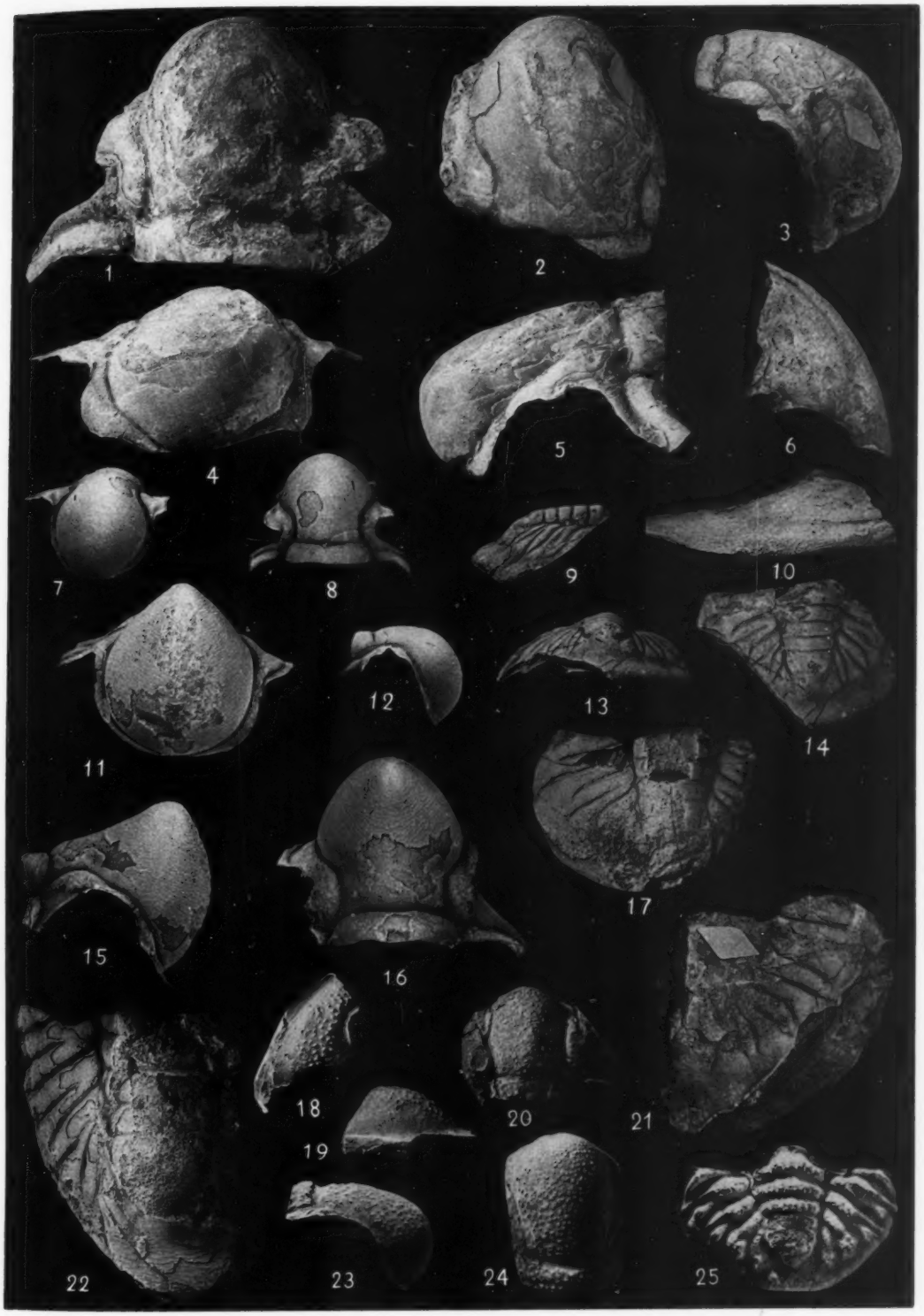
Discussion.—Ross (1951, p. 69) previously pointed out the similarities between *Goniotelina williamsi* and *Goniotelus perspicator*. These include a) cephalic outline; b) narrow cephalic border (which only in *Goniotelus* extends on to the genal spine); c) course of facial suture and shape of anterior part of rostrum (compare Pl. 68, fig. 10, with Pl. 68, fig. 11, and Ross, 1951, Pl. 14, fig. 22); d) the way in which genal spine is attached at genal angle (compare Pl. 68, fig. 9 with Ross, 1951, Pl. 14, fig. 19); e) form of pygidium—the terminal spine in *G. perspicator* is a prolongation of the axis as much as is that of *G. williamsi* (compare Pl.

EXPLANATION OF PLATE 66

FIGS. *1–10, 12–14, 17, 21, 22*—*Bolbocephalus seelyi* (Whitfield), Cassin formation, Fort Cassin, Vermont. *1, 4, 5*, lectotype, internal mold of incomplete cranidium, original of Whitfield, 1886, Pl. 33, figs. 12, 13, dorsal, anterior, left lateral views, ×1. AMNH 494a. *2, 3*, internal mold of incomplete cranidium, original of Whitfield, 1886, Pl. 33, fig. 14, dorsal, right lateral views, ×1. AMNH 494b. *6, 10*, internal mold of incomplete right free cheek, original of Whitfield, 1886, Pl. 33, fig. 15, dorsal and right lateral views, ×1. AMNH 494c. *7, 8, 12*, cranidium, anterior, dorsal, right lateral views, ×2. USNM. *9, 13, 14*, internal mold of incomplete pygidium, original of Whitfield, 1886, Pl. 33, figs. 16, 17, right lateral, posterior, dorsal views, ×1. AMNH 494e. *17*, internal mold of incomplete pygidium, original of Whitfield, 1886, Pl. 33, figs. 16, 17, dorsal view, ×1. AMNH 494d. *21*, pleural region of pygidium, original of Whitfield 1886, Pl. 33, fig. 18, dorsal view, ×1. AMNH 494f. *22*, incomplete pygidium with exoskeleton, dorsal view, ×1½. AMNH 494d. (p. 655)

11, 15, 16—*Bolbocephalus* ? sp. ind. Incomplete cranidium, anterior, right lateral, dorsal view, ×2. Cassin formation, Fort Cassin, Vermont. USNM. (p. 657)

18–20, 23–25—*Petigurus nero* (Billings). *18, 19*, internal mold of incomplete left free cheek, dorsal, left lateral views, ×1. Divisions F, G, H, St. George series, Keppel Island, western Newfoundland. GSC 8444d. *20*, internal mold of incomplete cranidium, dorsal view, ×1. Division G, St. George series, Port aux Choix, western Newfoundland. GSC 637a. *23, 24*, lectotype, internal mold of glabella, original of Billings, 1865, figs. 243a, b, right lateral and dorsal views, ×1. Division H, St. George series, Table Head, western Newfoundland. GSC 750. *25*, internal mold of pygidium, original of Billings, 1865, fig. 243c, dorsal view, ×1. Division G, St. George series, Port aux Choix, western Newfoundland. GSC 637. (p. 658)



Whittington, *Bolbocephalus*, *Bolbocephalus*? *Petigurus*

Whittington, *Uromystrum, Strigigenalis, Grinnellaspis? Psephosthenaspis*

68, figs. 5–8 with Ross, 1951, Pl. 14, figs. 16, 17). Chief differences between the two species are a) glabella of *G. perspicator* expands slightly between eye lobes, possesses glabellar furrows, and is more convex, descending vertically to anterior border furrow; b) eye lobe of *G. perspicator* is relatively longer, less strongly curved, and closer to glabella; c) pygidium of *G. perspicator* lacks strong axial furrows and has fewer pleural furrows. Evidently *Goniotelus* and *Goniotelina* are related, the former genus being probably the younger.

Formerly Ross (1951, pp. 68–69) regarded *Goniotelina williamsi* and *Eleutherocentrus petersoni* as congeneric. It seems to us now that *Eleutherocentrus* differs more strongly from either *Goniotelus* or *Goniotelina* than these two genera do from each other. *Eleutherocentrus* (text-fig 5) has a) cephalic outline smoothly rounded anteriorly; b) glabella narrowing between eye lobes; c) relatively shorter (exs.) eye lobe, placed farther forwards, and no palpebral rim; d) rostrum (if text-fig. 5 is correct) of quite different outline and convexity; e) wider pleural regions of pygidium, the maximum width one and a half that of axis, not about equal. In all these characters *Eleutherocentrus* differs from both the other genera, and how closely it may be related to them is difficult to estimate. Only the hypostomes of *Eleutherocentrus* and *Goniotelina* are known, and they show considerable similarities (compare Pl. 69, figs. 4–6, 9, 10 with Pl. 68, figs. 16, 17). That of *Eleutherocentrus* has the lateral margins converging posteriorly, and the posterior margin more transverse, with the spines at the corner. The long upward extension of the anterior wing is triangular in lateral view, with a broad base, rather than strap-like.

Published species which we consider probably belong to *Goniotelina* include the following:

1) *G. moorei* (Raymond, 1913, pp. 35–36, Pl. 3, figs. 7, 9, 10, 11, non fig. 8, this hypostome being more probably that of an asaphid), from the Lower Ordovician Beauharnois formation, St. Anne de Bellevue, Quebec.

2) *G. bøggildi* and *G. crassicornis* (Poulsen 1927, pp. 301–303, Pl. 20, figs. 19–25; 1946, p. 327) from the ostracod horizon of the Nunatami formation, upper Canadian of Northwest Greenland and Ellesmereland.

3) A cranidium from the Cassin formation, Fort Cassin, Vermont (Pl. 69, figs. 1,

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EXPLANATION OF PLATE 67

FIGS. *1–5, 10—Uromystrum validum* (Billings). *1, 2, 4*, lectotype, incomplete exfoliated cephalon, left lateral, ventral, dorsal views, ×1. Division L, Table Head series, Pointe Riche, Newfoundland. GSC 642. *3, 10*, exoskeleton with cephalic borders and right cheek missing, original of Raymond, 1925, Pl. 3, fig. 19, left lateral and dorsal views, ×1½. Table Head series, west side Gargamelle Cove, Newfoundland. MCZ 1643. *5*, pygidium showing doublure on left side, dorsal view, ×1½. Table Head series (?), upper Tier, first point west of beach, Port au Port, Newfoundland. MCZ 3422. (p. 659)

6–8—Strigigenalis cassinensis Whittington, n. gen., n. sp. Holotype cephalon, dorsal, right lateral, anterior views, ×2. Cassin formation, Fort Cassin, Vermont. USNM. (p. 671)

9, 13–15—Bathyurellus nitidus (Billings). *9, 13*, plaster cast of lectotype, exoskeleton with anterior part of cephalon missing, original of Billings, 1865, p. 265, fig. 249, right lateral, dorsal views, ×3. Division P. Cow Head conglomerate, Cow Head, Newfoundland. GSC 645e, b (counterpart). *14, 15*, incomplete cepahalon (*15* is plaster cast), dorsal and right lateral views, ×2. Horizon and locality as figs. 9, 13, GSC 645c. (p. 661)

11, 12, 16–18, 21–23, 26, 27—Strigigenalis abdita Ross, n. gen., n. sp. Silicified specimens from lower half of zone G_2, Garden City formation, Ross, 1951, locality 6, Utah. *11, 12, 17*, cranidium, dorsal, anterior, left lateral views, ×7½. YPM 18735. *16*, incomplete cranidium, interior view, ×5. YPM 18736. *18*, incomplete left free cheek, interior view, ×5. YPM 18740. *21, 22, 23*, left free cheek, dorsal view, ×6½, anterior and lateral views, ×4. YPM 18737. *26*, pygidium, ventral view, ×8. YPM 18738. *27*, pleura of segment, interior view, ×10. YPM 18739. (p. 671)

19, 20, 24, 25, 28, 29—Psephosthenaspis strenua (Billings). *19, 20, 25*, incomplete cephalon, left lateral, anterior, dorsal views, ×3. Boulder at St. Antoine de Tilly, Quebec. GSC 839. *24, 28, 29*, incomplete cephalon, dorsal, right lateral, anteroventral views, ×2. Locality as figs. 19, 20, 25, GSC. (p. 674)

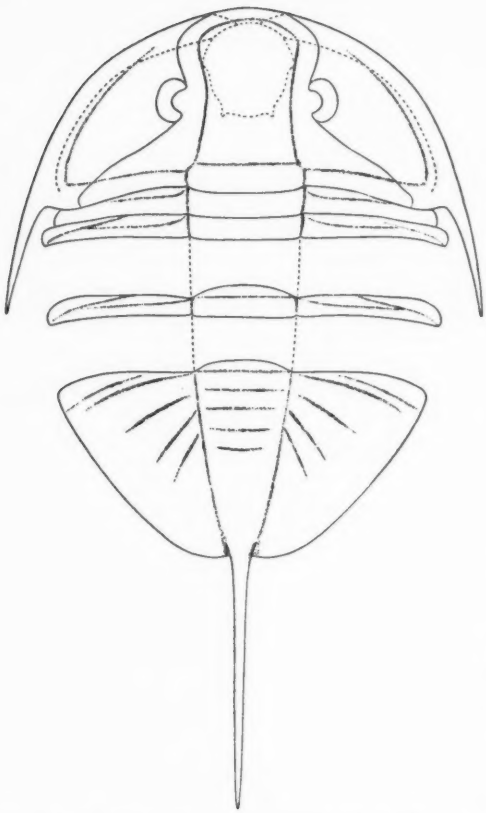


FIG. 5—*Eleutherocentrus petersoni* Clark. Reconstruction of exoskeleton in dorsal view, based on specimens on slab MCZ 5095 (including original of Pl. 69, fig. 3) and hypostome from YPM 18741–3. The inner margin of the cephalic doublure, course of the connective sutures, and outline of hypostome are shown in dotted lines. Number of thoracic segments unknown, but spacing based on nine. Size is slightly greater than largest specimens known.

2, 7, 8), here regarded as conspecific with "*Petigurus*" *subrectus* Bradley (1925, pp. 5–6, Pl. 1, fig. 3) from Quebec. The pygidium here shown in Pl. 68, figure 31, from the same horizon and locality, may belong with this cranidium.

4) The cranidium of "*Jeffersonia*" *jennii* Cullison (1944, pp. 76–77, Pl. 35, figs. 17–20), from the upper Canadian of Missouri and Arkansas (the pygidium associated with this cranidium by Cullison (1944, Pl. 35, figs. 21, 22) does not appear to be of *Goniotelina* type), and *G. marionensis* (Cullison, 1944, pp. 83–84, Pl. 35, figs. 32–37), from the high Canadian of Arkansas.

5) The species *G. brighti*, *G. brevus*, *G. wahwahensis* and *G.* sp. D, from the high Canadian of western Utah (Hintze, 1953, pp 158–161, pl. 26, figs. 1–14).

The geographical range of this genus is further extended by material in the U. S. National Museum from Pennsylvania, Oklahoma, and Alberta, and it is this material that Ulrich had in mind when he communicated with Strand (1932, p. 163).

GONIOTELINA WILLIAMSI (Ross), 1951
Plate 68, figures 11, 13–21

Eleutherocentrus williamsi Ross, 1951, pp. 69–71, Pl. 14, figs. 16–22, 25.

Paratypes figured here.—YPM Nos. 18744-18750 incl.

Occurrence.—Garden City formation, zone "J," locality 13 (Ross, 1951, pp. 22–23, 27–28, 71).

Description.—Discovery of a rostral plate, identification of a hypostome, and reexamination of paratype and topotype material make mandatory further comment on, and slight alteration of, the original description of this species.

Rostrum (Plate 68, figs. 11–13).—A peculiarly shaped structure, it is subtriangular in anterior view; convex on its anterior face and ventrally continues the rounded "prow" of the cephalic border (Ross, 1951, plate 14, figs. 20–22). Posteriorly it curls under and upward to conform to rolled doublure of cheeks (Pl. 68, fig. 15). Posterior extension essentially a blunt "spoon," being concave on the posterior side. To produce this structure connective sutures run downward across border converging; they come closest to one another after passing ventral side. As they run upward on posterior side of doublure they diverge strongly. This course is clearly reflected in the anteroproximal tips of free cheeks (Pl. 68, figs. 15, 21). Top of rostrum on front of border delimited by rostral suture; posterodorsal edge knife-like and almost certainly limited by hypostomal suture. External surface of rostrum horizontally ornamented with same coarse Bertillon lines that characterize border and doublure of free cheeks (Pl. 68, fig. 15).

Panderian organs (Pl. 68, figs. 14, 18)—Evidence for Panderian openings found in the form of a rectangular notch in the doublure of each free cheek, located between base of genal spine and posterior facial suture. On tips of pleurae notches in posterior edges of doublures served to limit enrollment and may not have functioned as Panderian openings.

Hypostome (Pl. 68, figs. 16, 17).—Oval outline and bearing a remarkable pair of long, slender, dorsally directed anterior wings. These arise from margin approximately opposite midlength of hypostome. Convex middle body incompletely divided by middle furrows: no maculae developed. Distinct furrow separates subtubular border from middle body; posterolaterally minute posterior wings, dorsally directed, present, and in lateral view (Pl. 68, fig. 17) border is notched between anterior and posterior wings. Surface covered with an irregular Bertillon pattern.

Discussion.—The type and other species here placed in *Goniotelina*, homeotypic material of *Eleutherocentrus petersoni* Clark, and topotypes of *Goniotelus perspicator* (Billings) show that Ross (1951, p. 69) placed too much weight at the generic level on the characteristics of the terminal pygidial spine. The species of *Goniotelina* show that the spine does not stem directly from the tip of the axis, but partly from the border and partly from the axis, and the pleural regions are drawn out and involved in the spine base to varying degrees. The length and thickness of the spine also varies and in one species (*Goniotelina crassicornis* Poulsen) there is hardly any spine at all.

The hypostome of this species was at first considered to be unique in the remarkable extension of the anterior wings into slender appendifers. However, these are now known also in *Eleutherocentrus petersoni* Clark and in a species of the genus *Licnocephala* Ross (1951, p. 109). They require that the hypostome be tilted posteroventrally at a fairly steep angle and were probably fastened by muscular tissue beneath the dorsal furrows. It is possible that the hypostome was fastened along its anterior edge by flexible tissue or ligament, as suggested by Whittington (1941, pp. 514–517); the fact that all specimens are very thin and appear frayed along the anterior edge between the appendifers may be the result of incomplete calcification and flexibility along the hypostomal suture.

From the four Utah species *Goniotelina williamsi* is distinguished either by the features of the pygidium (character of terminal spine or number of pleural furrows) or by convexity of the glabella. From *G. crassicornis* Poulsen it differs in the size of the terminal spine and in the shape of the genal spines.

Genus PLATYANTYX Whittington, n. gen.

Type species.—*Bathyurus arcuatus* Billings, 1865.

PLATYANTYX ARCUATA (Billings), 1865
Plate 68, figures 22–29

Bathyurus arcuatus BILLINGS, 1865, p. 205, fig. 190.
Bathyurus arcuatus RAYMOND, 1913, p. 57.

Holotype and other material.—Six incomplete cranidia are included under the numbers GSC 866, 866a–d, and 866a, the largest most complete specimen, is possibly the holotype and original of Billings' figure 190. Billings' types were listed as missing at the time of my visit to Ottawa (September, 1951), but, through the kindness of Dr. Alice E. Wilson, these specimens, collected by J. Richardson, were located, and most probably they are Billings' originals. The almost complete specimen, numbered 866, referred to by Raymond, was also located. All the specimens are from the boulder near St. Antoine de Tilly, Lotbinière Co., Quebec (see Appendix).

Description.—Dimensions of GSC 866a in millimeters: length (sag.) of cephalon, 4.5: length (exs.) of cephalon, 10.5; maximum width of cephalon, approx. 11.5; height of cephalon, 3.7; length (sag.) of glabella, 3.9; maximum width of glabella, 2.9; width of occipital ring, 2.4; length of eye lobe, 1.6. Glabella expands forwards, gently convex transversely, strongly convex longitudinally so that frontal lobe slightly overhangs anterior border. Occipital ring longest (sag.) in midline, defined by a gently curved, deep occipital furrow. Maximum width of glabella at about one-quarter length, and the

anterolateral margins of frontal lobe are straight, the tip rounded, giving a characteristic bluntly-pointed outline to anterior lobe. Lateral margins of glabella straight and run directly forwards just in front of occipital ring. Opposite a point about half length of eye lobe the straight sides diverge to maximum width. One pair of short glabellar furrows present, running inwards and slightly backwards, commencing at about half the length, i.e., just in front of where glabella begins to expand forwards. These furrows are unornamented areas, scarcely depressed, on external surface (Pl. 68, fig. 22), but internal molds show them as shallow depressions (Pl. 68, fig. 28). Axial furrows shallow, best developed anteriorly where they merge with preglabellar furrow. Eye lobes long, situated a short distance from glabella and close to posterior border furrow. Inside eye lobe the cheek horizontal transversely, longitudinally gently convex, so that it slopes down to posterior border furrow. Outside eye lobe cheek gently convex, steeply sloping, sloping most steeply anterolaterally, and continuous with gently convex, steep preglabellar field. The latter shortens (exs.) towards midline, where it is almost absent (Pl. 68, figs. 23, 24). Cheek with broad border, flat and horizontal anterolaterally, dipping in slightly to midline, and at genal angle border merges with genal spine to form a broad (tr.), concave, outwardly sloping base to the spine, which narrows rapidly. Posterior border short (exs.), convex, lengthening at base of genal spine, border furrow moderately deep, dying out at genal angle. Palpebral lobe slopes inwards, and has a narrow rim, highest point lower than glabellar midline. Facets of eye-surface shown in Pl. 68, fig. 26. A low eye ridge runs inwards and forwards to reach axial furrow at about one-third glabellar length. Anterior branch of facial suture runs at first forwards and outwards, then curves inwards to cross border and reach anterior margin at the exsagittal line which passes through extremity of occipital ring. Doublure flat, horizontal or gently sloping to a point beneath inner margin of cephalic border, then sharply flexed to slope inwards and upwards. Anteriorly it appears to be recurved, so that the inmost part slopes upwards and forwards. Course of sutures on doublure and hypostome unknown.

Thorax and pygidium known from the single, small complete specimen only (Pl. 68, figs. 28, 29). Thorax apparently of nine segments, axis moderately convex. Inner parts of pleurae horizontal. Outer parts of pleurae of first four or five segments slope gently, cut off by steeply-sloping facets, and sharply pointed. Outer parts of pleurae of remaining segments flexed more strongly down at fulcrum, but distal portion flattened, giving a concave profile, in conformity with pleural regions of pygidium. Facet smaller, and tips blunt. Pleural furrow deep and broad, and runs straight out. Pygidium short, triangular in outline, width twice length (excluding terminal spine). Axis broken, but apparently extends almost to tip and prolonged into terminal spine. Inner part of pleural region convex, steeply sloping, outer part flattened and gently sloping, no border furrow. Three pleural furrows, not reaching margin, two interpleural ribs reaching margin and a faint third rib. External surface of glabella and cheeks with relatively large, low tubercles. Cephalic border, genal spines, thorax and pygidium apparently smooth.

Discussion.—I am not aware of any other described species that may be placed in *Platyantyx*. A relationship between *Goniotelina* and *Platyantyx* is suggested by the likeness in glabellar outline, length of preglabellar field, size and position of eye lobes, and form of the pygidium. The broad, flat cephalic border and form of the genal spines distinguish *Platyantyx*.

Genus ELEUTHEROCENTRUS Clark, 1935

Type species.—by original designation, *Eleutherocentrus petersoni* Clark, 1935.

ELEUTHEROCENTRUS PETERSONI Clark, 1935
Plate 69, figures 3–6, 9, 10; text-figure 5

Discussion.—The reconstruction is based upon specimens collected from the maroon and green shales in the lowest part of the Swan Peak formation, at Round Hill, north of Mantua, Logan quadrangle, Utah (locality 13 of Ross, 1951, pp. 22–23). It agrees with Clark's description (1935, pp. 243–245, Pl. 24, figs. 12–19) except that the pygidial spine is longer than Clark stated it to be.

One specimen (Pl. 69, fig. 3) shows the anterior doublure of the free cheek, which is acutely pointed, the point not reaching the midline. The anterior edge of the pointed portion is the connective suture. The posterior edge is curved convexly forwards, and I consider that the hypostome fitted against this edge as well as the posterior edge of the rostrum, as indicated in text-figure 5. Hypostome (Pl. 69, fig. 4–6, 9, 10; material collected by Ross, from quartzitic sandstones at his (1951, p. 13) locality 2) suboval in outline, strongly convex transversely, gently convex longitudinally, greatest width across tips of anterior wings and equal to length (sag.). Maximum width at midlength. Anterior margin strongly curved. Behind the wings lateral margins are at first gently convex outwards forming the shoulders, and then converge back to join the gently curved posterior margin at an obtuse angle. Short spine at posterolateral corner. No anterior border. Lateral and posterior borders narrow, gently convex, and defined by broad, shallow furrows. Middle furrow shallow, and commencing at base of anterior wing, runs inwards and backwards at a small angle to margin, but does not reach mid-line. Posterior lobe of middle body thus crescentic in outline, and having a convexity independent from that of anterior lobe. Anterior wing triangular, long (tr.), broad (exs.) at base, and directed steeply upwards. Tiny posterior wings developed, and in lateral view (Pl. 69, fig. 9) margin between wings is notched.

The relationships between *Eleutherocentrus*, *Goniotelus* and *Goniotelina* are discussed under the latter genus.

Ross (1951, pp. 68–69) pointed out that *Goniotelina williamsi* is not an asaphid because it lacks the characteristic median suture. For the same reason *Eleutherocentrus* is not an asaphid, but the dorsal exoskeleton is like that of certain asaphids, e.g. the older species *Xenostegium franklinense* Ross (1951, pp. 102–103, Pl. 24, figs. 8–14, Pl. 25, figs. 1–5). Tentatively, on the assumption that the median suture (and type of hypostome) is diagnostic of Asaphidae, *Eleutherocentrus* is here regarded as a bathyurid.

Genera and species either inadequately known or of uncertain affinities.—*Acidiphorus* Raymond, 1925, type species by original designation *Acidiphorus spinifer* Raymond, 1925 (p. 131, Pl. 8, figs. 15, 17; this paper, Pl. 68, fig. 12). Only the pygidium known, from beds with *Leperditia*, in the lower Table Head series, Table Head, Newfoundland. In general form and external ornament it is similar to that of *Goniotelus perspicator* (Pl. 68, figs. 5–8). The distinct axial rings, pleural furrows, and border ally it also with the pygidium of *Goniotelina williamsi* (Ross, 1951, Pl. 14, figs. 16, 17). Until the remainder of the exoskeleton is known it is impossible to say whether or not *Acidiphorus* is a bathyurid, but if so, it may be related to, or perhaps congeneric with, either *Goniotelus* or *Goniotelina*, n. gen.

Bathyurina Poulsen, 1937, type species by original designation, *Bathyurina megalops* Poulsen, 1937 (pp. 51–52, Pl. 6, figs. 14, 15, Pl. 7, fig. 1), from the Cape Weber formation, highest Canadian, East Greenland. Only incomplete cranidia known. Glabella expands slightly forwards, three (or four?) glabellar furrows faintly indicated. Eye lobe large, the short preglabellar field steeply inclined and overhung by the convex pseudofrontal glabellar lobe. This species is like several of those here placed in *Goniotelina*, and in particular *G. jennii* (Cullison), but is distinguished at once by the presence of short glabellar furrows. When the remainder of the exoskeleton of *Bathyurina* is known it will be possible to decide whether or not *Goniotelina* is generically distinct from *Bathyurina*.

Other species.—"*Jeffersonia*" *granosa* Cullison (1944, pp. 72–73, Pl. 34, figs. 17–22) has one pair of glabellar furrows, and a long (sag.) preglabellar field. The pygidium associated has a narrow border and spines on the axial rings. The cranidium referred to "*J.*" *mediacrista* (Cullison, 1944, pp. 74–75, Pl. 34, figs. 25–27) is of similar type, but the associated pygidium has a broader border than that of "*J.*" *granosa*. Neither of these species can be referred to *Peltabellia* n. gen., *Goniotelina* n. gen., or to *Bathyurina*. A further type is represented by "*J.*" *producta* Cullison (1944, pp. 73–74, Pl. 34, figs. 1–9). It is allied to, but perhaps not congeneric with, the *Peltabellia* type, and distinct from the *granosa-mediacrista* type.

The foregoing illustrates the difficulty of assigning to the genera described in the systematic section published species based upon dissociated cranidia and pygidia. It also indicates the existence of additional species and genera of probable bathyurid affinity, the material of which is inadequate for description at this time. The variety of the associated pygidia is at present baffling. As discussed above, four types of pygidia were placed in "*Jeffersonia*" by Cullison. Two further types (Cullison, 1944, Pl. 35, figs. 25, 26 and 36, 37) were referred to "*Goniotelus*" by Cullison. One, that of "*G.*" *marionensis*, has been placed in *Goniotelina* n. gen. The second, that of "*G.*" *semicircularis*, is similar to the originals of "*Bathyurus*" *caudatus* Billings (1865, p. 261, fig. 245) from the upper Canadian of western Newfoundland, to a specimen in the U. S. National Museum from the Cassin formation at Ft. Cassin, Vermont (Pl. 68, figs. 30, 32), to Raymond's (1913, p. 66, Pl. 7, figs. 11, 12) "*Goniurus*" *elongatus* from the upper Canadian of Quebec, and to Ross's specimen (1951, Pl. 15, fig. 12) from the upper Canadian of Utah. This widespread type of pygidium is apparently of restricted range in time, but at present the remainder of the exoskeleton is unknown.

Family LEIOSTEGIIDAE Bradley, 1925

Discussion.—Study of the type material of the Lower Ordovician genera *Leiostegium* Raymond, 1913, *Lloydia* Vogdes (1890, p. 97; Raymond, 1913, pp. 66–67), and of the illustrations given by Rasetti (1944) of species of the Upper Cambrian genera *Lecanopyge* Raymond, 1937, and *Platycolpus*, Raymond, 1913 (this name is a synonym of *Platycolpus* Donald, 1900, and a new name is being proposed elsewhere by Dr. C. Lochman), suggests to me that they may be related. I have tentatively used the oldest family name known to me for this group, partly in the sense in which it was used by Kobayashi (1935) and Raymond (1937). Ross (1951, p. 121), in describing the specimens from the Lower Ordovician here named *Strigigenalis abdita* n. gen., n. sp., called attention to their similarity to *Platycolpus*. The cranidium of *Strigigenalis* is distinguished from that of *Platycolpus* by the less well-defined glabella anteriorly and the longer (sag.) preglabellar field. The remainder of the cephalon cannot be compared and contrasted from published illustrations, but in *Strigigenalis* there appears to be a rostrum, whereas Dr. Rasetti informs me (personal communication) that in *Platycolpus* the doublure is continuous anteriorly, without median or connective sutures. The pygidium of *Platycolpus* is like that here referred to *Strigigenalis*.

Psephosthenaspis n. gen. is distinguished from *Strigigenalis* by the more parallel-sided glabella, having a forwardly-expanding appearance, well defined anteriorly, and the short (exs.) preglabellar field. In these features it is allied to both *Platycolpus* and *Leiostegium*. The presence of the rostrum distinguishes it from the former, while *Leiostegium* has the eyes much farther out on the cheeks. The tubercular ornament of *Psephosthenaspis strenua* is apparently a unique feature among known members of this group.

Work by other authors is in progress on the older genera discussed above, and pending publication of the results the affinities here suggested must be regarded as tentative. The six genera have a superficial resemblance, but the available material of any one species is incomplete, generally consisting of isolated cranidia, and in some cases associated pygidia. If this is a natural group it appears earlier and stands somewhat apart from typical bathyurids, but may be related to them. Such a relationship is suggested by at least the type species of *Peltabellia* n. gen. (Ross, 1951, Pl. 17, figs. 7, 8, 12, 13, 16–22), which has features in common with *Strigigenalis* and others of this group. These include outline of the glabella, length of preglabellar field, size and position of eye lobe, presence of a cephalic border anteriorly which is less distinct laterally, and the broad shallow furrow curving over the free cheek.

Genus STRIGIGENALIS Whittington & Ross, n. gen.

Type species.—*Strigigenalis cassinensis* Whittington, n. sp.

Discussion.—Characteristic of the cephalon is the sub-parallel-sided glabella, rounded in front and faintly defined by a shallow preglabellar furrow, the large eyes, the long

(sag.) preglabellar field, the narrow (sag.) cephalic border anteriorly, which disappears laterally, and the broad, shallow, border furrow curving over the free cheek. The cephalic sutures of *S. abdita* Ross, n. sp., indicate that a rostrum is probably present.

STRIGIGENALIS CASSINENSIS Whittington, n. sp.

Plate 67, figures 6–8; plate 69, figures 23–25

Holotype.—U. S. National Museum, cephalon, from the Cassin formation, Fort Cassin, Vermont.

Description.—Dimensions of holotype in millimeters: length (sag.) of cephalon, 8.2; width of cephalon, 15.8; height of cephalon, about 7.0; length of glabella, 7.9; width of glabella at base, 5.8.

Cephalon semicircular in outline, gently convex. Glabella parallel-sided, rounded anteriorly, gently convex (tr. and sag.) defined by shallow axial and still shallower preglabellar furrows. Occipital furrow deep in median part, shallow laterally, median part of occipital ring highest part of glabella. Cheeks and preglabellar field continuous, gently convex, steeply sloping anteriorly, less steeply laterally. Eye lobe long, gently curved, midpoint situated opposite a point slightly behind midlength of glabella. Palpebral lobe without furrow and rim, sloping gently inward and continuous with fixed cheek. Eye surface with tiny, diagonally arranged facets. Anterior branch of suture runs forwards and slightly outwards to border furrow, then turns to run diagonally inwards and downwards over the vertical face of border (Pl. 67, fig. 8). Posterior branch runs diagonally outwards to cut posterior margin at more than half width of cheek. Anteriorly a short (sag.) rolled cephalic border, defined by a deep furrow. Anterolaterally this border dies out, and border furrow becomes shallow, curving inwards over free cheek and joining posterior border furrow. Short, broad-based genal spines present.

Anterior border and doublure with raised lines on external surface, subparallel to margins. Occipital ring with faint median tubercle, and, adjacent to posterior margin, raised lines running in curves convex forwards. Shallow, scattered pits occur at genal angle outside border furrow. Elsewhere exoskeleton smooth.

Rostrum, hypostome, and thorax unknown.

Associated pygidium.—E. O. Ulrich, in his manuscript notes on the U. S. National Museum collections, associated with this cephalon the pygidium shown on Pl. 68, figures 30, 32. However, Ross, in describing *S. abdita* n. sp. (see below), points out that the *Strigigenalis* cephalon in Utah is always associated with a pygidium of the same type as that from Fort Cassin shown in Pl. 69, figs. 23–25. The latter is the same as that described by Whitfield (1890, pp. 37–38, Pl. 2, figs. 6–8) as *Bolbocephalus ? truncatus*, and is here tentatively assigned to *S. cassinensis*. The cephalon on which *S. cassinensis* is based has not been called *S. truncata* (Whitfield), because this would mean that the diplotype of *Strigigenalis* would be a pygidium, an undesirable situation. Until a complete specimen is found the association is regarded as tentative, but probable.

The specimens (Pl. 69, figs. 23–25) are internal molds, but show the features described by Whitfield—low axis, squarely terminated, convex pleural regions without border, first pleural furrow distinct, second faint. Doublure (Pl. 69, fig. 25) broad, reaching in to tip of axis, inner part flexed steeply upwards.

As noted above Cullison (1944, Pl. 35, figs. 30, 31) referred a pygidium of the type here placed in *Strigigenalis* to *Bolbocephalus*. It may be that this pygidium represents a species of *Strigigenalis*.

Discussion.—Poulsen (1927, pp. 302–303) mentioned a manuscript species of Ulrich's named "*Goniurus cassinensis*" from the Cassin formation at Fort Cassin. These specimens are those above referred to *Goniotelina subrectus* (Pl. 69, figs. 1, 2, 7, 8), including the pygidium shown in Pl. 68, figure 31, and not the material described here as *Strigigenalis cassinensis*.

STRIGIGENALIS ABDITA Ross, n. sp.

Plate 67, figures 11, 12, 16–18, 21–23, 26, 27

Platycolpus ? sp., Ross, 1951, p. 121, Pl. 29, figs. 22, 23, 25–34; Pl. 30, figs. 12, 13, 16.

Holotype.—YPM No. 18202.

Paratypes.—YPM Nos. 18203–18205, 18211, 18223, 18735–18740.

Occurrence.—Garden City formation, northeastern Utah, lower half of zone "G(2)," Ross's localities 5, 6, 7 (1951, pp. 14–18, 121). Specimens figured here from locality 6, at slope distance of 2,615 feet south of formation's base along crest of ridge; computed to be 709 feet stratigraphically above the base.

Description.—Cephalon semicircular in outline; moderately convex in anterior and lateral profiles. Genal angles rounded. Surface smooth. Border furrow distinct on cranidial portion but fading almost completely on free cheeks. Glabella subrectangular in outline, broadly rounded in front, low, gently convex, lacking all but occipital furrow. Axial furrows distinct but shallow, confluent around front of glabella. Length of glabella approximately three times its width in cephala 9.0 millimeters long; its length only 1.3 times the width in those 2.0 millimeters long. Preglabellar field very slightly convex and deflexed at an angle of 60° from the glabellar base. In lateral profile slope of glabella and of preglabellar field virtually confluent (Pl. 67, fig. 17; Ross, 1951, Pl. 29, fig. 23). Midlength of preglabellar field about one-fifth that of glabella; field bounded distally by shallow border furrow and raised border. Border narrow (sag.) with nearly vertical anterior face at midline; this face curves increasingly downward and under the margin at greater distances from the midline (Pl. 67, figs. 22, 23) as a part of the doublure.

Facial sutures run anteriorly from eyes with slight curvature (Pl. 67, figs. 11, 21; Ross, 1951, Pl. 29, fig. 27), turning sharply inward at marginal furrow to run proximoventrally along front of rim for short distance (Pl. 67, figs. 12, 21, 22). Sutures then turn in obtuse angle to become confluent horizontally (Pl. 67, figs. 12, 16) as rostral suture. However, connective sutures intersect facial sutures at these obtuse angles running more steeply downward in proximoventral and posterior direction across semitubular doublure (Pl. 67, figs. 21, 22). Presence of broadly triangular, undercurved rostrum is therefore inferred.

Facial sutures posterior to eyes run distally and posteriorly in gently curving course close to posterior border furrows (Pl. 67, fig. 11), then cut margin inside rounded genal angle.

Free cheeks with low, moderately convex eyes, lacking infraocular rings. Ocular platforms gently convex, limited distally by faint trace of border furrow (Ross, 1951, Pl. 29, fig. 26). Position of border furrow coincides with edge of doublure on ventral side (Pl. 67, fig. 18). Doublure of cheek deeply notched by Panderian organ within genal angle (Pl. 67, fig. 18); anterior edge of notch raised to act as enrollment "stop."

EXPLANATION OF PLATE 68

FIGS. *1–10*—*Goniotelus perspicator* (Billings), boulder at St. Antoine de Tilly, Quebec. *1, 2*, holotype, incomplete partially exfoliated cephalon, original of Billings, 1865, fig. 191, dorsal and right lateral views, ×3. GSC 847. *3, 4, 9*, cephalon, *3, 9*, dorsal left lateral views, ×6; *4*, surface of left eye lobe, ×15. GSC. *5, 7*, exfoliated pygidium, original of Raymond, 1913, Pl. 7, fig. 10, dorsal and left lateral views, ×3. GSC 7836. *6, 8*, pygidium, dorsal, left lateral views ×4. GSC. *10*, exfoliated cephalon, anteroventral view, ×4. GSC. (p. 662)

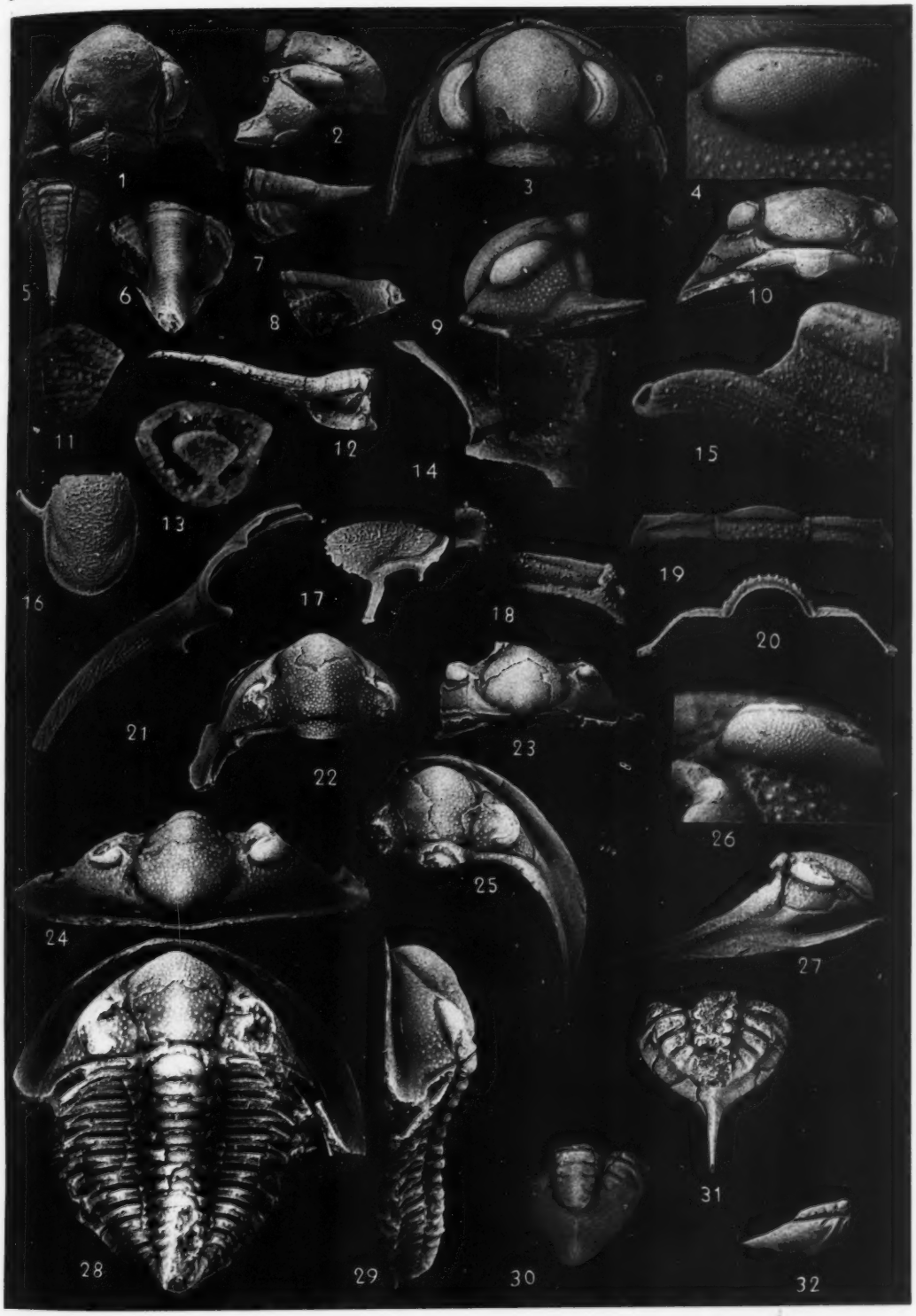
11, 13–21—*Goniotelina williamsi* (Ross). Silicified specimens from zone J, Garden City formation, Ross, 1951, locality 13, Utah. *11, 13*, rostrum, anteroventral, posteroventral views, ×25. YPM 18747. *14, 21*, free cheek, interior view of genal angle, ×15, dorsal view, ×5. YPM 18744. *15*, exterior view of anterior portion of free cheek, ×15. YPM 18745. *16, 17*, hypostome, ventral, right lateral views, ×7½. YPM 18748. *18*, left pleura of segment, interior view, ×10. YPM 18750. *19, 20*, thoracic segment, dorsal and anterior views, ×5. YPM 18749. (p. 666)

12—*Acidiphorus spinifer* Raymond. Holotype pygidium, original of Raymond, 1925, Pl. 8, fig. 17, right dorsolateral view, ×3. Beds with *Leperditia*, Table Head series, Table Head, Newfoundland. YPM 13028. (p. 669)

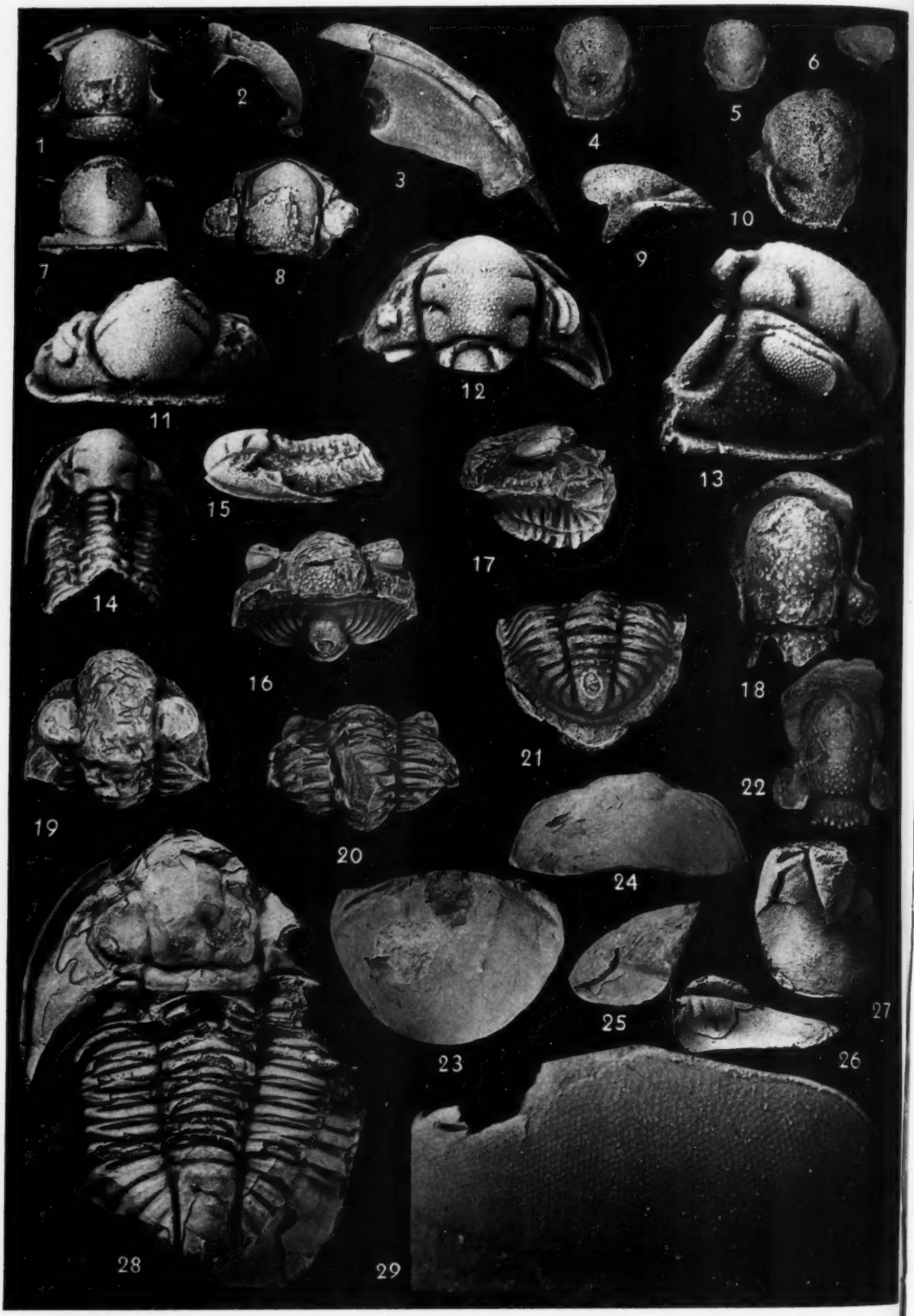
22–29—*Platyantyx arcuata* (Billings). Boulder at St. Antoine de Tilly, Quebec. *22, 23*, incomplete cephalon, dorsal, anterior views, ×2. GSC 866b. *24, 28, 29*, almost complete exoskeleton, anterior, dorsal, left lateral views, ×6. GSC 866. *25, 26, 27*, holotype ? incomplete cephalon, original of Billings, 1865, fig. 190? *25, 27*, dorsal, right lateral views, ×4, *26*, surface of right eye lobe, ×15. GSC 866a. (p. 667)

30, 32—Gen. et sp. ind., exfoliated pygidium, dorsal and right lateral views, ×1½. Cassin formation, Fort Cassin, Vermont. USNM. (p. 670)

31—*Goniotelina subrectus* ? (Bradley). Exfoliated pygidium, dorsal view, ×1½. Cassin formation, Fort Cassin, Vermont, USNM. (p. 666)



Whittington, *Goniotelus, Goniotelina, Acidiphorus, Platyantyx*, Gen. ind.



Whittington, *Bathyurina? Eleutherocentrus, Idiorhapha, Raymondites, Strigigenalis, Bathyurellus, Bathyurus*

Thoracic segments with furrowed pleurae. Tips pointed and with wide doublure; doublure notched by Panderian organ in same manner as rear of free cheek (Pl. 67, fig. 27).

Pygidium almost quarter-spherical. Axis prominent at front, but fading into pleural regions at rear. Axial segments obscure or lacking, apparently five in number when present. No border furrow or border. Doublure covering over one-half ventral side of exoskeleton (Pl. 67, fig. 26). Articulating bosses weakly developed beneath articulating facets at anterolateral corners.

Discussion.—*Strigigenalis abdita* is similar to *S. cassinensis*, but the rounded genal angles of the former distinguish it at once. Some of the material from the upper Canadian of western Utah, described by Hintze (1953, pp. 242–243, Pl. 9, figs. 13–15, 18; Pl. 13, figs. 13–17) as "Undetermined genus and species B" and "C" comes from essentially the same horizon as *S. abdita*, and probably represents an additional species of *Strigigenalis*.

Genus PSEPHOSTHENASPIS Whittington, n. gen.

Type species.—*Bathyurus strenuus* Billings, 1865.

Discussion.—This genus is proposed for the single species from the boulder at St. Antoine de Tilly, Quebec. *Psephosthenaspis* n. gen. and *Strigigenalis* n. gen. both have the sub-parallel-sided glabella, large eyes situated well back, the narrow anterior cephalic border disappearing laterally, and the broad shallow furrow curving over the free cheek. In both genera the sutures are opisthoparian, and the anterior branch runs forward to the margin of the border, then inwards and downwards over the vertical edge of the border to meet the rostral suture. The rostrum is short (sag.), broad (tr.), and convex. *Psephosthenaspis* n. gen. is distinguished from *Strigigenalis* n. gen. by the slight forward expansion and greater convexity of the glabella, which is well defined anteriorly by a deep preglabellar furrow; and the short (exs., almost absent in the midline) preglabellar field.

EXPLANATION OF PLATE 69

FIGS. *1, 2, 7, 8—Goniotelina subrectus* (Bradley), Cassin formation, Fort Cassin, Vermont. *1, 2, 7*, incomplete cranidium, dorsal, right lateral, anterior views, ×1½. USNM. *8*, incomplete cranidium, dorsal view, ×1½. USNM. (p. 665)

3–6, 9, 10—Eleutherocentrus petersoni Clark. *3*, free cheek, interior view, ×2. Swan Peak formation, Ross, 1951, locality 13, Utah. MCZ 5095. *4*, internal mold of hypostome, ventral view, ×2. Swan Peak formation, Ross, 1951, locality 2, Utah. YPM 18743. *5, 6*, internal mold of hypostome, ventral, ventrolateral views, ×2. Horizon and locality as fig. 4. YPM 18741. *9, 10*, internal mold of incomplete hypostome, right lateral, ventral views, ×4. Horizon and locality as fig. 4. YPM 18742. (p. 668)

11–15—Idiorhapha solitaria (Billings). Boulder at St. Antoine de Tilly, Quebec. *11–13*, cephalon' anterior, dorsal views, ×9, lateral view, ×15. GSC. *14, 15*, holotype, plaster cast, dorsal, left lateral views, ×4. GSC 852. (p. 675)

16–21—Raymondites ingalli (Raymond). North side of landspur, northeast corner of St. Joseph's Island, Quebec, Canada. *16, 17, 19, 20, 21*, incomplete enrolled exoskeleton, anterior, left lateral, dorsal, posterior, dorsal (of pygidium), views, ×1½. USNM. *18*, incomplete cranidium, dorsal view, ×1½. USNM. (p. 654)

22—Raymondites sp. Cranidium, dorsal view, ×1½. "Upper Black River," Phelan and Jordan quarries, Dixon, Illinois. USNM. (p. 655)

23–25—Strigigenalis cassinensis Whittington, n. gen., n. sp. Cassin formation, Fort Cassin, Vermont. *23, 24*, exfoliated pygidium, dorsal, posterior views, ×1. USNM. *25*, pygidium, right lateral view, showing doublure, ×1. USNM. (p. 671)

26, 27—Bathyurellus abruptus Billings. Lectotype, incomplete, partly exfoliated pygidium, left lateral, dorsal views, ×2. Divisions F, G, H, St. George series, Port aux Choix, Newfoundland. GSC 648. (p. 660)

28—Bathyurus superbus Raymond. Incomplete exoskeleton, original of Raymond, 1910, Pl. 2, fig. 3, dorsal view, ×1. Pamelia beds, La Petite Chaudière, Mechanicsville, Ottawa, Ontario. ROMP 18788. (p. 653)

29—Raymondites longispinus (Walcott). Holotype, anterolateral surface of right eye lobe, ×15. Horizon and locality as Pl. 65, figs. 10, 14, 15, MCZ 3767. (p. 654)

PSEPHOSTHENASPIS STRENUA (Billings), 1865

Plate 67, figures 19, 20, 24, 25, 28, 29

Bathyurus strenuus BILLINGS, 1865, pp. 204–205, fig. 188.
Lloydia ? strenuus RAYMOND, 1913, p. 68.

Lectotype (here selected).—GSC 839a, a cephalon, presumably the original of Billings' fig. 188. From the boulder at St. Antoine de Tilly, Quebec (see Appendix).

Other material.—GSC 839, a smaller cephalon (Pl. 67, figs. 19, 20, 25); the incomplete cephalon here figured (Pl. 67, figs. 24, 28, 29); and various fragments, all from the same locality.

Description.—Cephalon subsemicircular in outline, moderately convex, maximum height (at the occipital ring) about equal to length (sag.). Glabella subrectangular in outline, moderately convex longitudinally, gently convex transversely, width across occipital ring and at anterior end of axial furrows about equal, but the slight narrowing of glabella immediately in front of occipital furrow gives the appearance of a forward expansion. Axial and preglabellar furrows shallow, occipital broad and deep. Two pairs of faint depressions, the first situated halfway between anterior margin and occipital furrow, the second halfway between the first and anterior margin, extend inwards a short distance from axial furrows. These are glabellar furrows, and they correspond in position with the two median pairs of scars of *Strigigenalis abdita* described by Ross (1951, p. 121, Pl. 29, fig. 31). Large eye lobe situated close to axial furrow and to the steep slope down to posterior border furrow. Cheek gently convex, and slopes steeply anterolaterally. Narrow (sag. & exs.) cephalic border, with a steep anterior face, well defined anteriorly but becoming smaller and less well defined laterally. From border furrow, at a point just outside the line of the axial furrow, a broad shallow furrow curves across cheek and joins posterior border furrow. Posterior border narrow (exs.) and, according to Billings, short genal spines are present. Posterior branch of suture runs out in a curve, cutting posterior margin just inside genal angle. Anterior branch runs forwards and slightly outwards to anterior margin of the border, then turns to run downwards and inwards across vertical face of border (Pl. 67, fig. 29). In anterior view, the junction, at an oblique angle, with the rostral suture is seen. Latter runs in a curving course across face of border. Connective suture runs downwards and inwards over rolled-under edge of doublure, making a slight angle with anterior part of anterior branch. Rostrum present, but missing in specimen shown on Pl. 67, fig. 29.

Close-spaced tubercular ornament on glabella and cheeks, tubercles largest on posterior part of glabella. The furrows, including glabellar furrows, but excluding that which curves over free cheek, are smooth.

Rostrum, hypostome, thorax and pygidium unknown.

APPENDIX: THE BOULDER FROM ST. ANTOINE DE TILLY, QUEBEC

Billings (1865, pp. 186–187, 188, 204–206) described the fossils collected by J. Richardson from a boulder at St. Antoine de Tilly, Lotbinière County, Quebec. They include four species of trilobites. One of these, *Goniotelus perspicator*, was made the type of new genus by Raymond, and two more, *Psephosthenaspis strenua* and *Platyantyx arcuata*, have been made the types of new genera in the foregoing pages. The fourth, "*Cheirurus*" *solitarius*, was not figured by Billings, but is illustrated here for the first time and made the type of a fourth genus. Three species of Gastropoda also come from the boulder, *Clisospira curiosa*, *Cyclonema phaedra*, and *Subulites psyche*. The first of these is the type species of the genus (Knight, 1941, pp. 79–80, Pl. 91, figs. 2a, 2b). Dr. Knight informs me (personal communication, May 2, 1952) that, with the exception of an undocumented report by Clarke of *C. curiosa*, none of these three species has been reported by any other author.

The St. Antoine boulder yielded a remarkable fauna, and the question of its age and occurrence is of considerable interest. In response to my inquiry, Dr. I. W. Jones, Chief, Geological Surveys Branch, Department of Mines, Quebec, replied (personal communication, May 26, 1952) that he had not been able to find anyone who knows anything specific about the boulder. He

quotes Dr. T. H. Clark's opinion that "the boulder referred to by Billings was a glacial erratic, and may have come from some exposure near Lévis." Dr. F. Rasetti gave me the following information (personal communication, April 28, 1952):

"I spent several days looking over the St. Antoine de Tilly area carefully in search of the mysterious boulder, and I am virtually certain that there are no conglomerate outcrops. Especially the bluffs along the St. Lawrence river, showing a continuous exposure, were examined for several miles both upstream and downstream from St. Antoine. All I could find were the Lower Cambrian shales (with interbedded sandstones) of the Charny formation, thrust over Upper Ordovician strata."

Dr. Rasetti also concluded that the boulder must have been an erratic. The specimens that I have seen are small chips of a light-colored, abundantly fossiliferous, coarsely crystalline limestone.

The age of the fauna has been given as "Beekmantown" by authors. Dr. J. B. Knight informs me (personal communication, May 2, 1952) that "*Clisospira* is not common in Canadian beds, but *is* in Middle Ordovician beds." *Cyclonema* is "unknown below Middle Ordovician," and likewise *Subulites*, except for its occurrence in the Lévis boulders. Dr. Knight concludes that the evidence "cumulatively points to a very high Lower Ordovician if not Middle Ordovician" age. Of the trilobites, only *Goniotelus* is known elsewhere, by an undescribed species in C. H. Kindle's collection from the early Middle Ordovician Cow Head conglomerate, at Lower Head, western Newfoundland. *Psephosthenaspis* and *Platyantyx* are here regarded as related to late Canadian genera. Thus the evidence of the trilobites supports Dr. Knight's opinion on the age of the boulder.

Genus IDIORHAPHA Whittington, n. gen.

Type species.—*Cheirurus solitarius* Billings, 1865.

IDIORHAPHA SOLITARIA (Billings), 1865
Plate 69, figures 11–15

Cheirurus solitarius BILLINGS, 1865, p. 206.

Holotype.—GSC 852, from boulder at St. Antoine de Tilly, Lotbinière County, Quebec.

Other material.—GSC collections, additional cephala including that figured here, same locality.

Description.—Dimensions in millimeters of holotype and original of Pl. 69, figs. 11–13, respectively: length (sag.) of cephalon, 2.9, 2.4; width of cephalon at genal angles, 5.6, approx. 5.0; maximum height of cephalon, 2.4, 2.2; maximum width glabella (at second furrows), 2.4, 2.2; width occipital ring, 1.9, 1.8; length of eye lobe, 1.1, 0.8. Glabella suboval in outline, strongly convex longitudinally, overhanging anterior border, moderately convex transversely. Occipital ring transversely ovate in outline, occipital furrow having a bow-shaped course deep and narrow at extremities, broader where it swings forwards to midline. Three pairs of glabellar furrows, distance (exs.) between extremities of first and second equal to distances (exs.) between first and extremity of occipital furrow, and second and anterior margin of glabella. Third situated at base of anterolateral slope, half-way (exs.) between extremity of second and anterior margin. First furrow deepest, running inwards diagonally in a curve, inner end not reaching occipital furrow. Second straight, running inwards and slightly back. Third short and faint. Axial furrows moderately deep, continuous with preglabellar furrow, no anterior pit present. Cheeks gently convex, steeply sloping laterally. In and near midline no preglabellar field present. A narrow (sag. and tr.) border, concave upwards and almost horizontal at edge, runs around cephalon and extends on to genal spines. No border furrow, and border is sharply rolled under. Convex posterior border defined by deep border furrow, which extends out close to, but does not reach, genal angle. Genal spine tapers rapidly and reaches to a point opposite fourth thoracic segment. Eye lobe long, gently curved, midpoint opposite glabella midpoint. Palpebral lobe consists almost entirely of broad rim and deep furrow. Eye surface convex (exs. and tr.), with many convex facets (Pl. 69, fig. 13). In front of, and in line with, palpebral rim is a low raised region on fixed cheek, which extends in to axial furrow. This seems to represent the eye ridge. Anterior branch

of facial suture (Pl. 69, fig. 11) runs straight out and down over cheek to border, then curves in across border to reach margin at a point in line (exs.) with midpoint of eye lobe. Further course of this suture unknown. Posterior branch runs outwards subparallel to border furrow, then just inside genal angle curves to cut posterior margin inside base of genal spine (Pl. 69, figs. 13, 15). Hinder part runs on a sutural ridge, and border furrow ends against inner margin of this ridge.

Hypostome, and rostrum if present, unknown.

External surface of glabella, and cheeks inside border, with close-spaced, low tubercles.

Seven segments of thorax present on holotype. Axis moderately convex. Inner part of pleurae sloping gently outwards, at fulcrum pleurae curved down to slope steeply, and extremity is bluntly pointed. Broad shallow pleural furrow runs directly outwards across inner part.

Discussion.—Idiorhapha solitaria has features which recall *Sphaerexochus*, a cheirurid genus which Öpik (1937, p. 91) regarded as standing alone in the subfamily Sphaerexochinae. Most obvious is the outline and convexity of the glabella, with the three pairs of furrows, though the convexity is not as great as in *Sphaerexochus*. The form and arrangement of the facets of the eye surface, and the presence of the sutural ridge, are cheirurid features, but not exclusively so. The opisthoparian suture, the flattened cephalic border, and the pleurae of the thorax, with transverse pleural furrows, are all non-cheirurid in aspect. We need to know the remainder of the exoskeleton of *I. solitaria* before judging relationships. I consider the sphaerexochinid appearance of *Idiorhapha* as more likely an example of homeomorphy than an indication of relationship.

The cephalon of *Idiorhapha*, and especially the glabella, shows some similarity to that of the opisthoparian Upper Cambrian genus *Acheilus* (see, for example, Rasetti, 1944, Pl. 36, figs. 23, 24, 27–33, 36, 39). Yet the cephalic border of *Idiorhapha* is different from that of *Acheilus*, and we cannot compare the entire exoskeletons. It is possible that *Idiorhapha* is an Ordovician descendant of *Acheilus*-type trilobites, but uncertain. Shaw (1952, p. 466) has suggested that the acheilid stock gave rise to the Sphaerexochinae. The exoskeleton of the Cambrian acheilids is incompletely known, and there is a long gap in time between the two groups, much longer than that shown in Shaw's figure 4. I am not aware of a sphaerexochinid older than early Middle Ordovician. On present evidence I regard this interpretation as unlikely.

I consider it more probable that *Idiorhapha* is related to the early Lower Ordovician form *Onchonotus foveolatus* Rasetti (1943, p. 103, pl. 19, figs. 4–6), the form and size of the cephalon, and size of eye lobes, being similar. *Idiorhapha* is distinguished by the relatively wider glabella with three (not one) pairs of glabellar furrows, and the flattened (not convex) cephalic border.

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PALEONTOLOGY OF RUSTLER FORMATION, CULBERSON COUNTY, TEXAS[1]

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ABSTRACT—The fossils described in this paper substantiate the Permian age of the Rustler formation. The Rustler fauna is largely mollusean and has a Whitehorse aspect. Four species of the Rustler fauna are similar to species from Russian and Indian faunas, suggesting possible correlations with Upper Permian rocks. Environments have had more influence on the fauna than has geologic age, giving the Rustler fauna a striking resemblance to faunas of older Permian rocks which occupied similar biotopes. The Rustler fauna is large and varied, containing 35 species of invertebrates. Because of the fragmentary condition of the fossils, many species are uncertainly identified.

FOREWORD

Ronald K. DeFord[2]

THE most distinctive member of the Rustler formation is the layer of limestone or dolomite that has been called the Culebra member (Adams, 1944, p. 1614). Its mean thickness in the subsurface of the Delaware Basin is perhaps 25 feet; it is present almost everywhere in the basin east of the outcrop in the Rustler Hills and extends beyond the rim of the basin to the north and the east. Recent field mapping has shown that Walter's member N is the Culebra member.

In a recent review of opinions about the age of the Rustler that have been published during the past 50 years (Donegan and DeFord, 1950) one item was overlooked. Stone (1920, p. 258) cited a letter from J. A. Udden dated February 6, 1917. Copies of the correspondence have been found in the file of the Bureau of Economic Geology, The University of Texas. The letter of February 6 addressed to Stone does not mention the Rustler; an earlier letter dated October 18, 1915, addressed to N. H. Darton, is the one referred to. The complete text is as follows:

> Your letter of the 14th is received. I am mailing you today a copy of my paper on Age of Castile Gypsum and Rustler Spring formation. I hope before long to be able to make another statement on this same subject. Mr. C. L. Baker and Dr. Böse, of this Bureau, have lately examined the formation for us, near Rustler Springs, and they report clear proof that the Rustler formation and the Castile gypsum is palaeozoic. The information is not given for publication, and I trust you will consider it confidential.

The living principals do not recall further details. Baker's field notes, not presently available, may contain additional information. "Another statement" (Udden, 1922) was made, but it did not mention the clear proof.

INTRODUCTION

The fossils collected by Donegan in 1947 (Donegan and DeFord, 1950) are undoubtedly Paleozoic, and by stratigraphic position therefore Permian, but they are so poorly preserved that taxonomic classification beyond the generic level is impossible. In the summer of 1950 John E. Wilson and the writer mapped the fossiliferous area and made additional collections from new and old localities. The summer work increased fossil collections, determined the local stratigraphic distribution of previously known fossil zones, and revealed a local gastropod zone in the lower member of the Rustler formation.

The fauna was collected from Culberson County, Texas, between the parallels N 31°30′ and 31°45′ and the meridians 104°10′ and 104°14′W; it also includes specimens from the lower member of the Rustler formation in the vicinity of U. S. Coast and

[1] Based on a thesis presented to the faculty of the Graduate School of The University of Texas in partial fulfillment of the requirements for the degree of Master of Arts, August, 1951.

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Geodetic Survey triangulation station "Harral" in the southwestern corner of Harral quadrangle.

Collections are the property of the Department of Geology, The University of Texas, Austin, Texas.

The writer is indebted to Ronald K. DeFord for his supervision and assistance, particularly in regard to stratigraphic problems in the Rustler formation; to James Lee Wilson for supervision of the paleontologic research; and to John A. Wilson for suggestions and assistance in the field.

Grateful thanks are extended to John E. Wilson, an excellent field partner; and to Ben Donegan, E. J. Travis and J. L. Hutchison who made their fossil collections available for study.

This paper has been critically read by Ronald K. DeFord, James Lee Wilson, and John A. Wilson. It has also been read by G. A. Cooper, Carl O. Dunbar, J. Brookes Knight, and Norman D. Newell.

METHODS OF COLLECTION AND PREPARATION

Collection.—The Rustler formation contains a large and varied fauna. Fossils obtained from the siltstone of the lower member are preserved as external casts or molds or by calcite replacement. Only the fossils replaced by calcite are sufficiently preserved to permit specific classification. The casts and molds attest to the varied fauna present, and yield added information about certain morphologic features not visible on the calcite-replaced species.

Specimens in the dolomite of the lower member are replaced by calcite and anhydrite. The best localities are where the dolomite is severely weathered and where it contains numerous nodules of the replacing materials.

In November, 1950, it was discovered that samples of the dolomite from locality No. 55–16 would yield excellent fossils of anhydrite when dissolved in hydrochloric acid (HCl). Previously the true value of the lower dolomite as a fossil bed had not been recognized. Only the calcite-replaced fossils that weathered out on the surface could be studied. A brief return to the locality to collect more of the etchable anhydrite fossils increased the quantity and quality of the fossil material available. Because of the hardness of the dolomite, attempts to remove the fossils by crushing were unsuccessful.

The fossils in the limestone of the lower member and member N exhibit the same type of preservation as those in the dolomite of the lower member, but with less calcite replacement. Samples of the limestones of these two members have yielded fossils even though their presence could not be detected at the surface.

Preparation.—Some specimens in the dolomite of the lower member are replaced by calcite; others are replaced by anhydrite. Although anhydrite is soluble in concentrated hydrochloric acid (HCl), removal of the anhydrite-replaced fossils was facilitated by dissolving the dolomite matrix in a dilute solution of hydrochloric acid, tech. (muriatic acid 33 percent by volume). Etching the anhydrite fossils destroyed any calcite-replaced fossils in the matrix, but the excellence of the anhydrite specimens obtained justified the destruction. After acidizing the dolomite, the extraneous material (silt and anhydrite particles) was decanted

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EXPLANATION OF PLATE 70

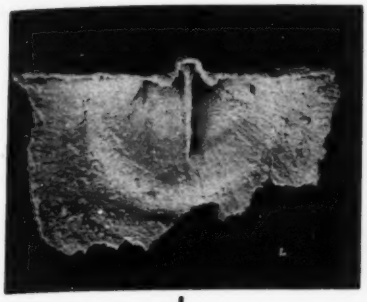
FIGS. *1, 3, 4, 7–9, 11—Derbya sulcata* Walter, n. sp. *1*, ventral interior showing median septum; *3*, cardinal area of ventral valve showing horizontal striae, grooved pseudodeltidium, and teeth, ×2; *4*, dorsal interior exhibiting bilobed cardinal process with bifid posterior extremities and bases of apophyses, ×2; *7*, oblique view of shell interior showing anterior convexity of well-developed apophyses-bearing crural plates, ×1½; *8*, posterior view of fig. *7*, ×1½; *9*, dorsal valve showing diverging crural plates and supports, ×3; *11*, dorsal exterior, showing intercalation of secondary and tertiary lirae, ×3. (p. 687)

2—Pleurophorus sp., interior view of left valve. (p. 692)

5—Echinoid spine, ×4. (p. 701)

6—Crinoid plate, ×2. (p. 701)

10—Euphemites sp. (a), showing inner whorl and closely spaced costae, ×3. (p. 696)



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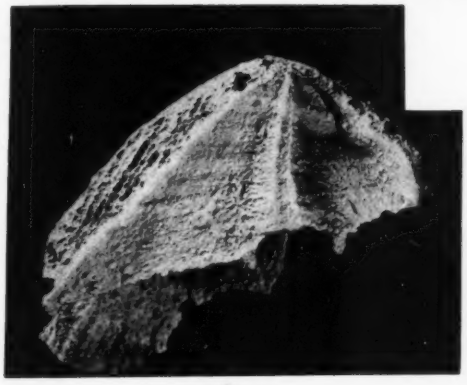

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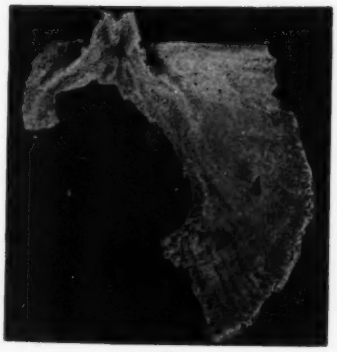

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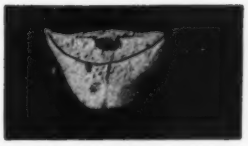

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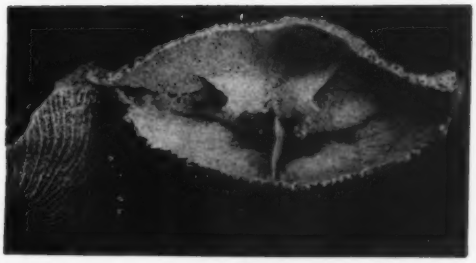

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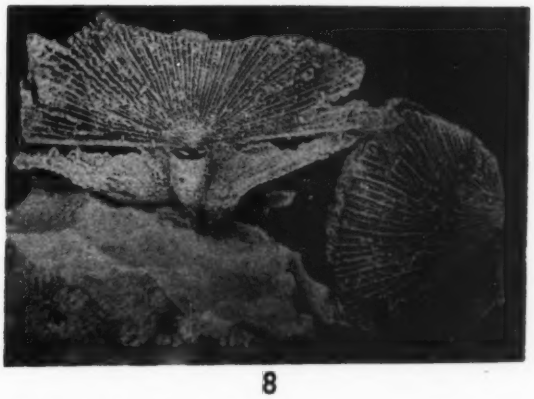

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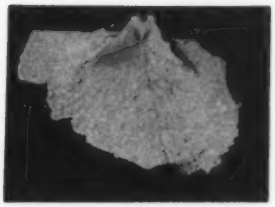

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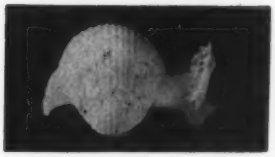

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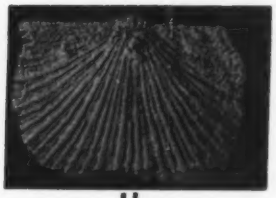

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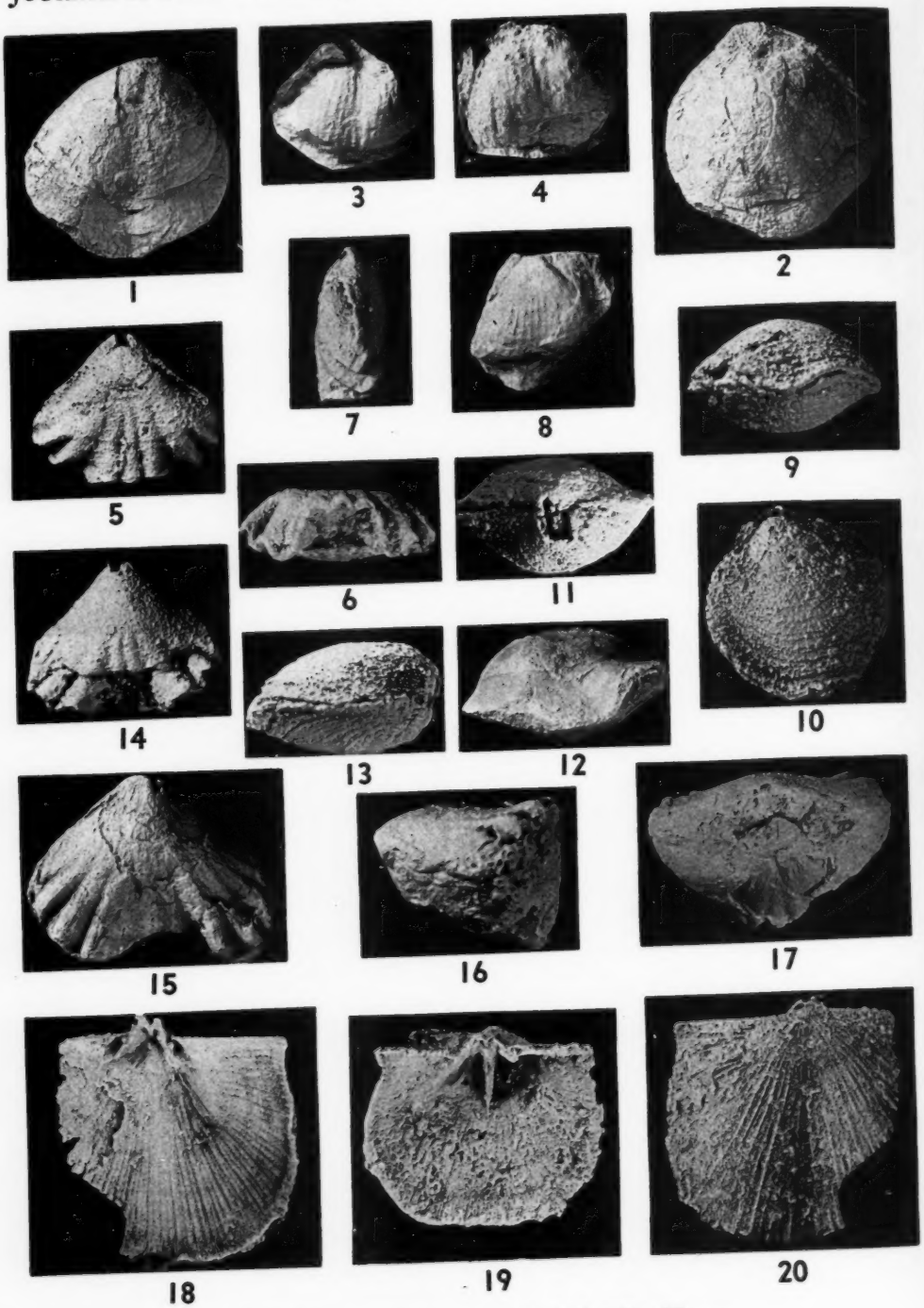
Walter, Permian (Rustler) fossils, Texas



Walter, Permian (Rustler) fossils, Texas

and fossils were dried. Samples of the decanted residue were analyzed for organic remains.

The anhydrite-replaced fossils in the silty limestone of the lower member and member N were etched with a dilute solution of muriatic acid (15–20 percent by volume) and strengthened with a thin Alvar solution.

Fossils preserved by calcite in the lower dolomite could not be studied unless exposed at the surface, because the poor preservation did not warrant the time consumed in removing the hard dolomite matrix.

A technique used in removing calcitic fossils from the surface of silty limestones and siltstones consisted of covering the fossil with solid potassium hydroxide (KOH) which reacts fairly promptly with the silty calcareous material to form a thick sludge but reacts with the crystalline calcite very slowly. A protective surface of Alvar insures preservation of the calcite fossils. The reaction requires 8 to 10 hours for completion. The technique is slow and requires repeated applications, but the condition of the specimens obtained warrants it as a desirable etching procedure.

All specimens photographed were first coated with magnesium oxide to bring out the detail of the ornamentation. The minute gastropods were not coated prior to photographing, as both magnesium oxide and ammonium chloride obscured their microscopic details of ornamentation.

OCCURRENCE OF BIOFACIES

There are four fossiliferous lentils in the Rustler formation. They are the dolomite, siltstone, and limestone lentils of the lower member, and the dolomitic limestone lentil of member N. Some of the fossils range through two or more of the fossiliferous lentils, while others are restricted to a single bed. The fossiliferous rocks are continuous throughout the area, except the dolomite lentil which is discontinuous north of Blk. 110, PSL.

The calcite- and anhydrite-replaced fossils in the lower member are the best preserved specimens in the formation. The irregular assortment, lack of orientation, fragility of some specimens, together with recovery of brachiopod specimens which are attached to each other, indicate that the fossils were preserved in situ. Incomplete specimens are due to inadequate replacement and not to the destructive effects of transportation.

Dolomite facies of the lower member.—The fossiliferous dolomite contains a balanced invertebrate fauna in which brachiopods, pelecypods, and gastropods were equally represented. The fossiliferous dolomite has yielded 20 forms of which 6 were brachiopods, 7 pelecypods, and 6 gastropods. The brachiopods are principally orthotetinid (*Derbya sulcata*) and rhynchonellid (*Wellerella*) forms. The pelecypods are not so numerous but are more varied. The most abundant genus is *Pleurophorus*.

The characteristic fauna of the dolomite lentil, in the lower member, though more abundant, has less variety in the southern portion of the area. At locality No. 55–16 there is an increase in the proportion of brachiopods but a striking decrease in the relative number of pelecypods and gastropods. Here the dolomite lentil is *underlain*

EXPLANATION OF PLATE 71

FIGS. *1, 2, 12—Composita* sp. *1*, ventral exterior ×1; *2*, dorsal exterior ×1; *12*, anterior profile ×1. (p. 690)

4—Productus ? sp. Ventral exterior; note medial sulcus and fine ornamentation ×1. (p. 691)

5–7, 14–17—Wellerella elegans (Girty). *5*, dorsal exterior ×3; *6*, anterior profile ×3; *7*, lateral view ×3; *14*, ventral exterior ×3; *15*, ventral exterior ×3; *16*, lateral view ×3; *17*, posterior profile ×3. Specimens *5–7* are crushed. (p. 689)

3, 8—Marginifera sp. ×1. (p. 701)

9–11, 13—Composita cf. *C. guadalupensis* ×2; *9*, anterior profile; *10*, dorsal exterior; *11*. posterior profile; *13*, lateral view. (p. 690)

18–20—Derbya sulcata Walter n. sp. *18*, dorsal interior ×3; *19*, ventral interior ×1½; *20*, dorsal exterior, same specimen as Fig. *18* ×3. (p. 687)

MEASURED SECTION
Loc. No 55–3
W. slope of hill in SW ¼, Sec. 11, Blk. 42, PSL., Culberson Co., Texas

	Thickness Feet
Rustler formation—	
Member N—	
11. Limestone, very hard, yellowish gray, thinly bedded, jointed, micrograined, contains anhydrite nodules and fossils. The thickness of the beds varies from 1 inch or less in the upper 2 feet of the unit to 4 to 8 inches in the lower portion. There is a random occurrence of large gastropods and numerous poorly preserved minute gastropods. .	19.0
Member M—	
10. Siltstone, medium hard, pale yellowish orange, thinly bedded, severely jointed, calcareous, platy on weathered surface	4.8
9. Limestone, very hard, pale red, massively bedded, sandy, coarse-grained, contains calcite veins; weathers to a rough irregular surface	1.5
8. Dolomitic limestone, very hard, moderate yellowish brown, massively bedded, brecciated, dense, medium to fine paurograined, contains anhydrite nodules. The upper 8 feet of the bed is grayish orange, and is medium crystalline and sandy	20.5
Bed 8 forms a massive bench throughout the area, appearing in many places as two benches due to differential weathering. This is the basal bed of member M.	
Lower member—	
7. Siltstone, hard, grayish orange, thinly bedded, finely muscovitic, highly calcareous. Closely resembles the underlying limestone on the weathered surface	8.9
6. Limestone, very hard, olive gray, thinly bedded, severely jointed, very fine to fine paurograined, contains fossils and weathers to a white calcareous deposit on the weathered surface	14.3
The fossils in this bed include *Pleurophorus* sp. (b), *Nuculopsis* (*Paleonucula?*) aff. *N. okawensis*, *Euphemites circumcostatus* Walter, n. sp., *Murchisonia ?* cf. *M. gouldii*, *Goniasma* sp., *Loxonematidae* (*Donaldina ?*), *Worthenia ?* sp., and others.	
5. Siltstone, medium hard, grayish orange, thinly bedded, severely jointed, finely muscovitic, calcareous; weathers to grayish orange, and has a limy crust on the severely fractured and weathered portions	23.8
The bed contains an abundant fauna characterized by *Derbya sulcata* Walter, n. sp., *Dictyoclostus ?* sp., *Marginifera* sp., Chonetids, *Hustedia* cf. *H. meekana*, *Myalina* sp., *Allorisma* aff. *A. dubium*, and plant fragments?	
4. Dolomite, very hard, grayish orange, massively bedded, contains gypsum nodules, fine calcite veins, and ferruginous stains on the weathered surface. The upper 4.7 feet are more thinly bedded and bear a white limy crust on the severely weathered portions	6.7
Fossils include *Derbya sulcata* Walter, n. sp., *Wellerella elegans* (Girty), *Euphemites circumcostatus* Walter, n. sp., *Murchisonia ?* cf. *M. gouldii*, *Goniasma* sp., and others.	
3. Quartz sandstone, hard, grayish orange, massively bedded, friable, very fine subangular grained, contains finely divided muscovite. This bed is slightly casehardened, bearing irregular fractures on the weathered surface	7.8
2. Gypsum, soft, white, massively bedded, granular; contains yellowish gray, wavy bands from 1 to 5 mm thick	12.7
1. Gypsum, soft, moderate red, massively bedded, leached in spots; contains undulating bands of gypsum from 1 to 5 mm thick. These bands were originally white and subsequently stained to grayish pink by the surrounding red material	4.2
Total thickness Rustler formation	124.2

by a siltstone lentil similar in lithic and faunal content to the siltstone lentil that *overlies* the dolomite lentil farther north.

Farther south, at U. S. Coast and Geodetic Survey's triangulation station Harral, the dolomite lentil is not present in the exposures of the lower member. It has either lensed out or graded into the siltstone facies at Harral. Nevertheless, the fauna in the siltstone at locality No. 55–19 (200 yards northwest of triangulation station Harral) contains the characteristic forms of the dolomite and siltstone assemblages at locality No. 55-16 (Rustler Spring area). No mollusks have been found at Harral, although scarce crinoid remains previously believed peculiar to the Rustler Spring area have been collected from the siltstone at locality No. 55-19 (Harral).

Siltstone facies of the lower member.—In the siltstone lentils of the lower member, 9 of the 13 species collected were brachiopods.

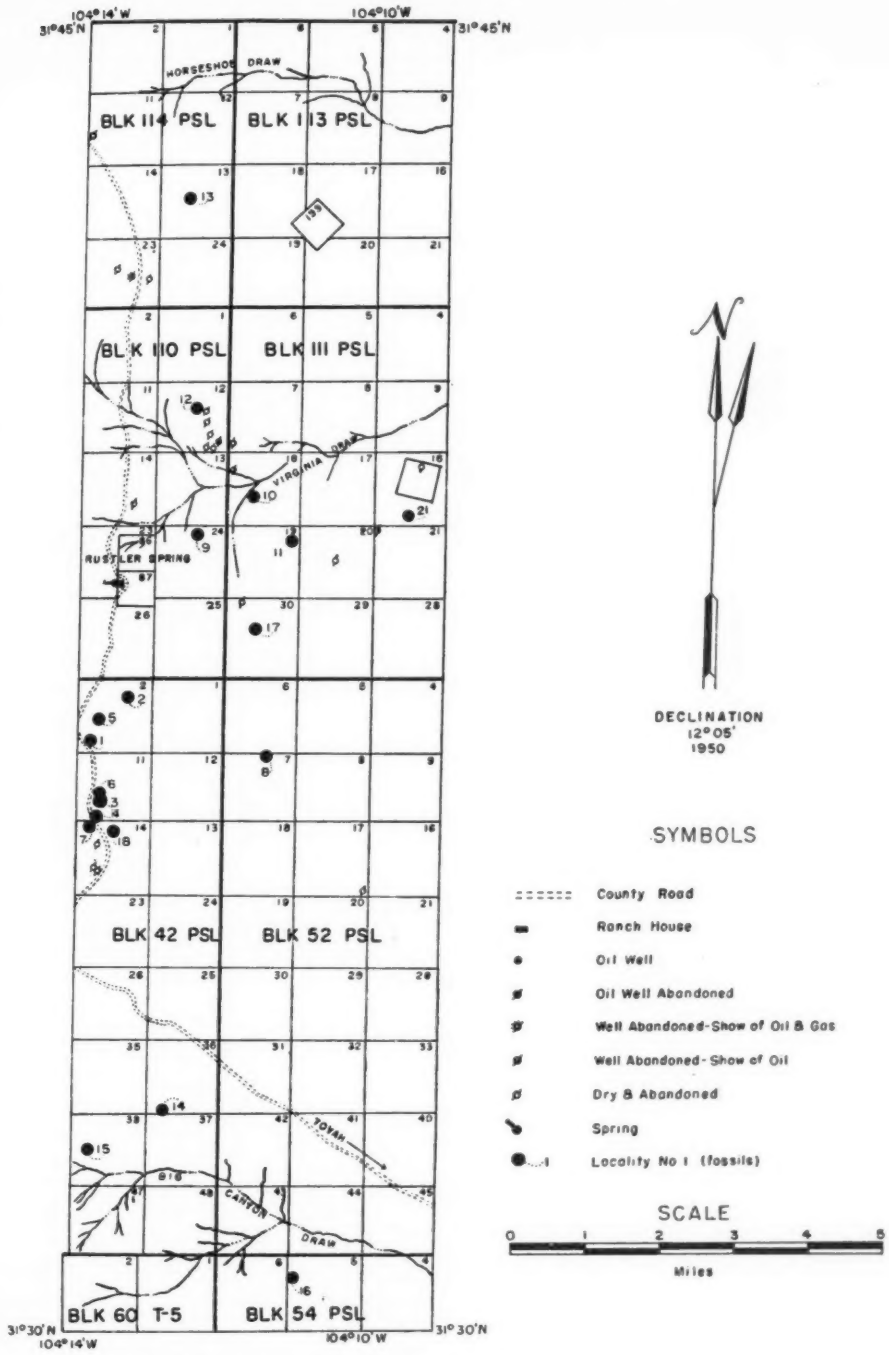


FIG. 1—Map of area investigated, showing localities where fossils were collected.

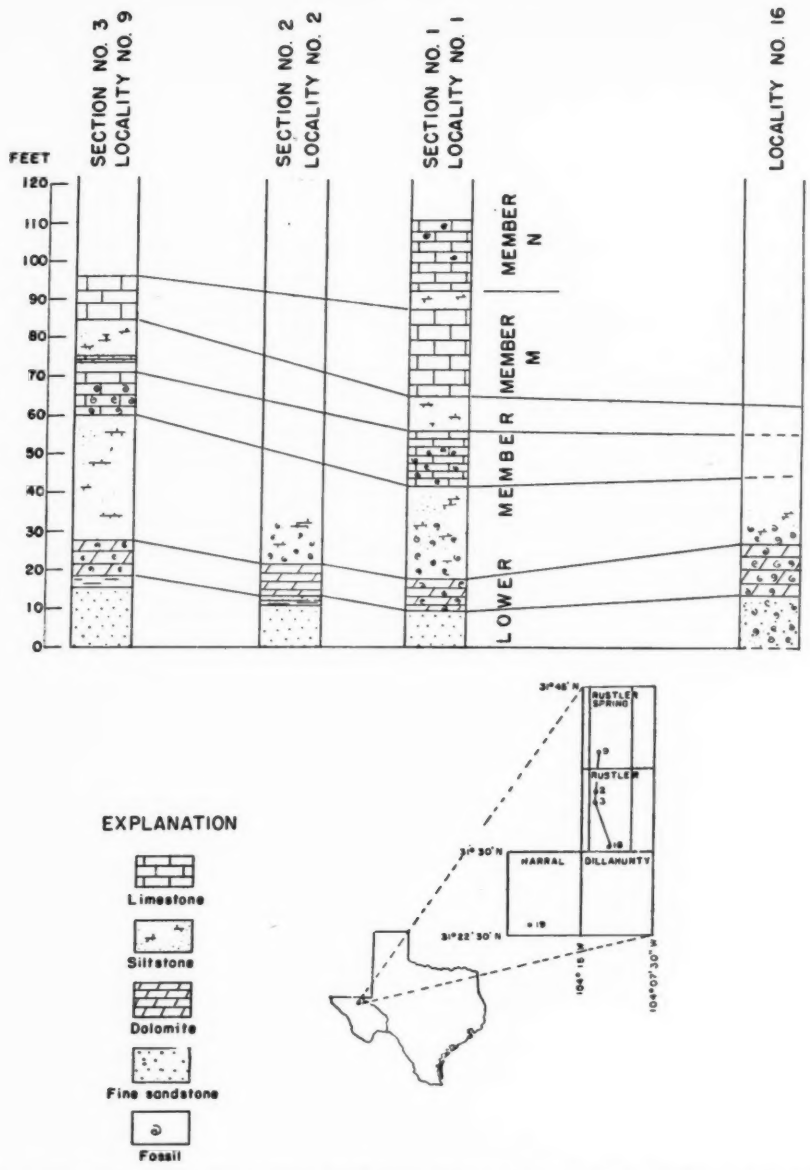


FIG. 2—Correlation of Rustler section, Culberson County, Texas. Datum: Base of sandstone lentil of lower member of Rustler formation. Horizontal distance not to scale.

Orthotetinid, productid, and rhynchonellid brachiopods comprise 70 percent of the specimens collected. "Plant fragments" are also abundant in the brachiopod-bearing siltstone. The uniform distribution, irregular arrangement, and thorough intermixing of the "plant fragments" with the invertebrate fauna indicate the "plants" are indigenous and occupied a shallow-water habitat. *Myalina* sp. and *Allorisma* cf. *A. dubium* occur in the siltstone, but no gastropods have been collected.

Fossils are plentiful in the basal portion of the siltstone and diminish in abundance

approaching the upper contact. In the vicinity of U. S. Coast and Geodetic Survey's triangulation station Harral at locality No. 55-19, fossils were collected from a 7- to 8-foot interval approximately 34.6 feet above the base of the siltstone.

It is probable that many of the species found in the dolomite also exist in the overlying siltstone, but they have not been found because of poor preservation. Should such species be found in the siltstone they would be associated with a more varied and abundant brachiopod fauna.

Limestone facies of the lower member.—The extremely fossiliferous limestone lentil of the lower member contains a fauna that is entirely molluscan. This unique Rustler assemblage is composed almost exclusively of gastropods. Of approximately 200 specimens (12 species) collected, there are but 12 specimens of pelecypods (three species), and five specimens of scaphopods (two species). *Euphemites circumcostatus* Walter n. sp. is the most abundant gastropod in the assemblage. Some of the gastropod genera (*Worthenia*? sp., *Murchisonia*? sp.) occur in the Whitehorse fauna, but no late Permian deposit of North America is known to have such a varied and populous gastropod fauna.

The exact stratigraphic limits of the limestone biofacies are not fully known, but fossils occur from the base of the limestone lentil (siltstone-limestone contact) to 11.5 feet above the base of the limestone at locality No. 55-3; the highest known occurrence is 9 feet below member M at locality No. 55-17.

The geographic extent of the limestone is unknown. The most northern collection came from the very fossiliferous limestone at locality No. 55-12. The limestone lentil is known to occur in the hills on the south side of Horseshoe Draw in the northeastern part of the area. It crops out in the hills on the north side of Big Canyon Draw in the southern portion of the area, but fossils have not been collected from these outcrops.

Fossils in the limestone lentil of the lower member were discovered in the summer of 1950. They were first observed at locality No. 55-17. The small size and abundance of the fossils allow a large number of specimens to be recovered from relatively small samples of the limestone. Very fossiliferous samples commonly have no surface indication of the fauna contained, and fossils are easily overlooked in the field.

Limestone facies of member N.—The fossiliferous limestone of member N contains a meager fauna of high-spired gastropods, but the specimens collected are too poorly preserved for definite identification. The fossils are mostly replaced by anhydrite, but a few external casts composed of limonite have been collected.

Although the specimens are not abundant, they have been collected from several widespread localities in the area. Their scarce, random occurrence prevents exact delineation of their stratigraphic limits. The limestone in this member is thinly bedded, silty, and contains a small amount of very fine-grained sand.

Figure 3, showing the stratigraphic and geographic distribution of the Rustler species, is a tabulation of all localities where fossils were obtained. Meager collections made while mapping were tabulated with the collections obtained from more thoroughly investigated localities. The apparent inconsistencies in the occurrence of certain species at some localities are due either to the local lack of an exposed fossiliferous lentil or to inadequate collections.

A large portion of the fauna remains undiscovered and further acidization of the rock containing the etchable fossils will increase the known fauna.

Fossil material from localities Nos. 55-1, 55-2, and 55-3 was supplemented with collections made by Ben Donegan during the summer of 1949.

The fossils from localities Nos. 55-19 and 55-20 in Harral quadrangle were collected by J. L. Hutchison and E. J. Travis.

VERTICAL RELATION OF BIOFACIES

The faunal assemblages obtained from the four fossiliferous lentils are characteristic of three distinct biotopes and are here considered as facies faunas.

The genera found in the dolomite lentil of the lower member suggest a marine environment. *Composita*, *Wellerella*, the pelecypod genera *Acanthopecten*, *Pleurophorus*, and the gastropod genera are known to occur only in marine assemblages (Newell, 1940). The dolomite is silty and limonitic, containing

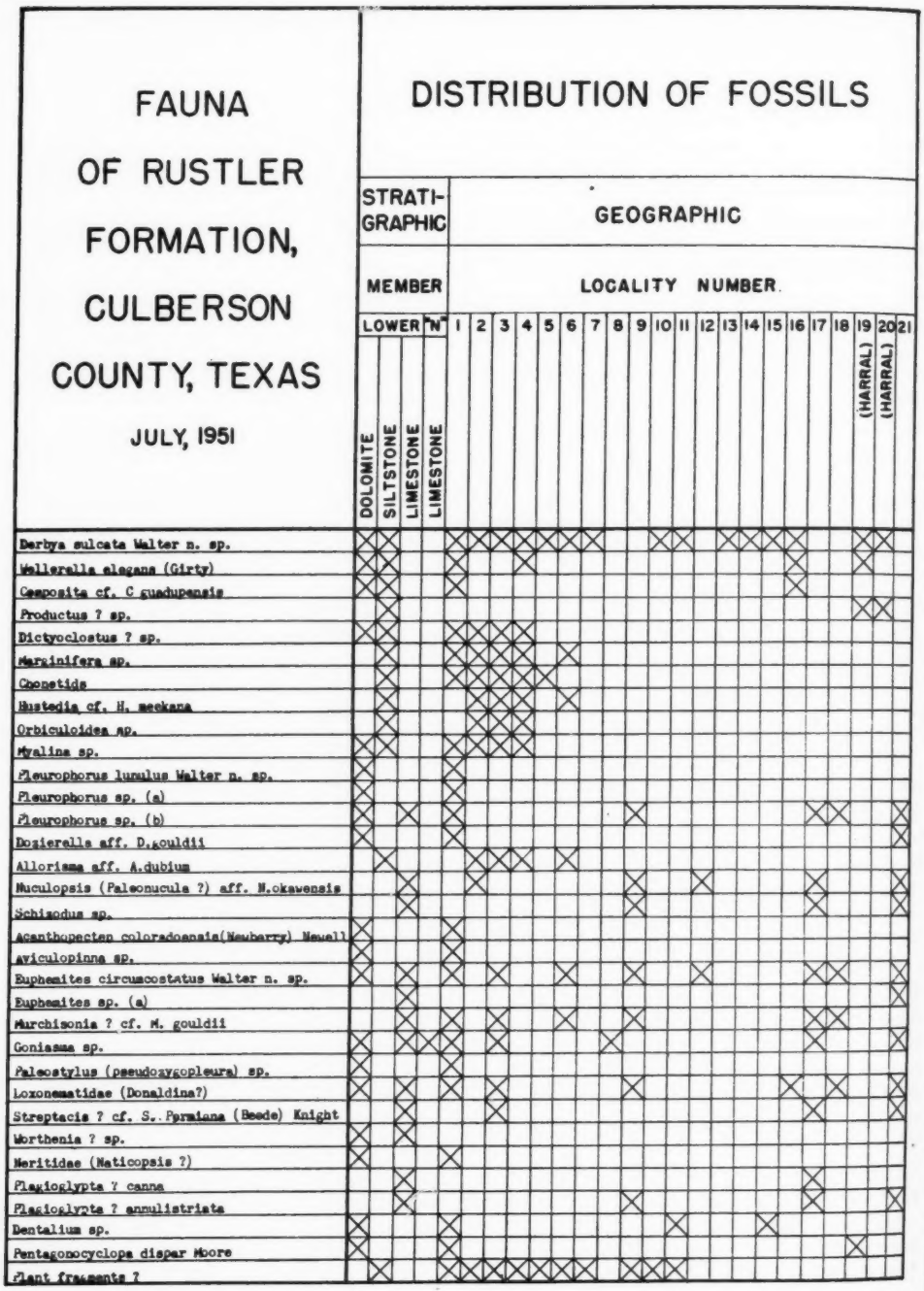


FIG. 3—Geographic and stratigraphic distribution of the Rustler fauna, Culberson County, Texas.

very small amounts of sand and varying amounts of anhydrite. The relatively fewer pelecypod and gastropod species and the abundance of orthotetinid brachiopods in the southern portion of the area indicate a variation in the normal marine biotope manifested by the facies fauna of the dolomite. This same lateral variation in environment, as indicated by faunal change, is seen in the back-reef facies of the Guadalupian series (Carlsbad formation) where certain characteristic Permian brachiopods are scarce or absent.

The fauna in the siltstone of the lower member is characterized by abundant and varied brachiopods, a small proportion of pelecypod species, and the absence of gastropods. Productids, chonetids, rhynchonellids, and the ubiquitous orthotetinid *Derbya* suggest a calcareous mud bottom habitat. The absence of anhydrite and abundance of marine brachiopods are indications that a normally saline environment existed while the siltstone was deposited.

The thin-bedded, silty limestone of the lower member and of member N contains principally gastropods. The severity of the biotope is evidenced by the large amount of anhydrite deposited, and is in agreement with the sulphatic condition of the sea during late Ochoan time. There is no doubt that the hypersaline water had a marked effect on the inhabitants and perhaps resulted in the aberrant biocoenose found in the limestone of the lower member and member N. The limestone contains a large molluscan fauna and no brachiopods, but the siltstone and dolomite usually considered molluscan lithotopes, contain principally brachiopods. This is additional evidence of the peculiar environment in which the limestone was deposited.

Certain gastropod species occur both in the limestone lentil and in the dolomite of the lower member. These species may be eurytropic and possibly would have been found in the intervening siltstone except for poor preservation. The rest of the underlying dolomite fauna does not occur higher either because the forms died out or migrated with a changing biotope. On the other hand, the gastropods may represent a recurring biofacies controlled by environmental factors of which we have no evidence. The fauna of member N is probably a relic of the recurrent gastropod fauna just discussed, for member M between the two is unfossiliferous.

AGE OF THE FAUNA

The Rustler fossils may constitute the youngest Permian fauna of North America. Because of its high stratigraphic position, there is perhaps no Permian fauna in this continent to which it can be precisely compared. It would seem that more fruitful correlations could be made with foreign Permian deposits of comparable age and stratigraphic position.

The Rustler species shown at the top of the next page bear comparison to foreign Permian faunas.

Although these species exhibit many similar morphologic features, in each form there are marked differences. As a result, contemporaneity can only be conjectured in these long-range correlations.

The comparison between the Rustler and Guadalupian species shows a striking resemblance between the Rustler and Guadalupian *forms* that occupy similar biotopes. These affinities are not limited to the Guadalupian faunas, for pronounced similarities can be recognized in the Phosphoria faunas.

The severe environment in which the Rustler, Whitehorse, and Blaine formations were deposited has had a more pronounced influence on their respective faunas than has geologic age.

The brachiopod fauna is diagnostic of neither time nor facies. With the exception of *Euphemites circumcostatus* Walter n. sp., which may be significant of the young age, the gastropods are not particularly diagnostic (Newell, written communication). Of the known Guadalupian faunas, those of the Whitehorse more closely resemble the Rustler molluscan fauna.

SYSTEMATIC DESCRIPTIONS

Phylum BRACHIOPODA

Genus DERBYA Waagen 1884 (emend. Girty 1908)

DERBYA SULCATA Walter, n. sp.

Plate 70, figures 1, 3, 4, 7–9

Plate 71, figures 18–20

Description.—Shell moderately biconvex with greatest thickness in uncrushed speci-

Comparable Rustler and Guadalupian Species

Rustler Species		*Guadalupian Species*
Composita cf. C. guadalupensis		= C. guadalupensis Girty Blaine
Wellerella elegans (Girty)		= W. elegans (Girty) Capitan
Dozierella aff. D. gouldii	similar to	D. gouldii (Beede) Whitehorse
Streptacis cf. permiana		=S. permiana (Beede) Knight Dozier Whitehorse
Murchisonia ? cf. M. gouldii		= M. gouldii Beede Whitehorse
Acanthopecten coloradoensis Newell		= A. coloradoensis Newell Word

Similar Species in the Rustler and Russian Faunas

Rustler Species		*Russian Species*
Aviculopinna sp.	similar to	Aviculopinna timanica Maslennikow Timan; Zechstein, Vymskii Basin
Murchisonia sp.	similar to	Murchisonia golowkinshyi Yakovlew Zechstein, Russian Platform

Similar Species in the Rustler and Indian Faunas

Rustler Species		*Indian Species*
Pleurophorus lunulus Walter, n. sp.	similar to	Pleurophorus subovalis Upper Productus Ls.
Allorisma aff. A. dubium	similar to	Allorisma dubium Upper Productus Ls.

mens about two-fifths distance to anterior margin.

Species highly variable in shape, of medium size. Mature shells, 2.5 to 3 cm long, young individuals much shorter. Many immature shells subquadrate in outline, but shell growth anteriorly with a lateral extension of the hinge-line results in a subcircular outline at maturity. Little information on ontogeny of shell is available from a single specimen, growth lines indistinct or absent. Hinge-line approximately equal to medial width of most immature shells but exceeds width of shell in some specimens. Cardinal extremities are obtuse. Anterior margin of shell not fully known, yet two specimens with complete margins exhibit an evenly curved outline with a very slight medial truncation when viewed dorsoventrally.

Dorsal valve moderately convex, attaining its maximum height one-third distance from beak, with slight depression or median sulcus from there to anterior margin. Although all specimens possess a dorsal sulcus, this feature is more pronounced on some individuals. Posterior extremities of dorsal valve flatten laterally. Cardinal area extremely narrow and linear. Umbo moderately tumid. Ventral valve less convex than dorsal; its greatest height one-third distance from anterior margin. Apsacline beak low and cardinal area one-third to one-fourth high as wide. Pseudodeltidium strongly convex; its sides form an angle of 30°. Shallow medial groove extends entire length of pseudodeltidium in some specimens. Perideltidial area not distinguishable, but entire cardinal area finely striated horizontally.

Surface marked by narrow, smooth, sharply rounded radial lirae separated by broad, flat-bottomed striae. Radial lirae increase by intercalation at margin of shells, where they number 19 to 14 lirae per cm, totaling 150 to 180. Moderate fasciculation of the lirae at anterior margin of shell. Primary and secondary lirae separated by tertiary and quaternary lirae, approximately one-half height of primary and secondary. Some individuals do not illustrate this fasciculation as well as others.

Internally, ventral valve has strong teeth which form ridges under each side of pseudodeltidium, no dental lamellae present. Strong median septum extends from beak one-third distance toward anterior margin. Median septum and "dental ridges" unite in apex of shell. Junction commonly obscured by callus-like deposit in apex of shell.

Construction of muscles unknown, impressions not visible on these thin shells.

In dorsal valve cardinal process large and bilobed, and changes shape as shell approaches maturity. In young shells cardinal process low, narrow, simply bilobed, and crural plates diverge anterolaterally to an angle of about 110°. Pronounced apophyses near anterior end of crural plate. Posterior extremities of cardinal process finely notched, even in youngest specimens collected. Muscle tracks on posterior face of cardinal process almost parallel to plane of commissure. With maturity, posterior face of cardinal process widens as it becomes higher with a "rapid" divergence of muscle tracks. Anterior portions of crural plates increase in length and height, with slight increase in divergence of crural bases; divergence accompanied by posterolateral trending of apophyses, resulting in a convex surface of crural plate when viewed from ventral interior, and concave surface when viewed from posterior. Anterior face of cardinal process at junction with crural plates forms shallow groove complementary in position with posterior muscle tracks.

Discussion.—The shapes of individuals in the same population differ appreciably. Although growth lines are indistinguishable on single specimens, comparison of shells of different sizes gives some indication of ontogeny. Many available specimens could not be used to determine shape because of crushing. In any event, the taxonomic importance of shape is doubtful. Dunbar and Condra (1938, p. 77) state:

> In delimiting species in this group we have found shape to be a character applicable only within broad limits and difficult to apply in many individual cases.

The most distinctive morphologic character of this species is the medial sulcus in the dorsal valve. Although the sulcus is not pronounced in all the dorsal valves collected, it can be distinguished in all specimens available for study. The radial lirae are smooth, narrow, and sharply curved on top; their height equals their width. The flat-bottomed striae are approximately twice as wide as the lirae.

Although the shape and outline of this species shows affinity to *Derbya arizonensis* McKee, which also has a median sulcus, the Kaibab species has fewer lirae per unit width and is coarsely ornamented. McKee did not describe the internal characters of his species.

Internally the cardinal process closely resembles that of *Derbya crassa*; nevertheless the greater divergence of the crural plates (110°), and the accentuated bending of the apophyses posterolaterally, and the shallowness of the muscle cavity should distinguish this species from *D. crassa*. External ornamentation and the median sulcus should distinguish the species from *D. buchi* and *D. cymbula*.

Occurrence.—*Derbya sulcata* (Sp. No. 1A and 1B) occurs in the dolomite and calcareous siltstone of the lower member of the Rustler formation.

Genus WELLERELLA Dunbar & Condra 1932
WELLERELLA ELEGANS (Girty) 1909
Plate 71, figures 5–7, 14–17

1909 *Pugnax elegans* GIRTY, U. S. Geol. Survey Prof. Paper 58, p. 317, pl. 15, figs. 13–14a.
1930 *Pugnoides elegans* (Girty). KING, Univ. Texas Bull. 3042, pl. 33, figs. 12–13; pl. 34, figs. 2–4, var. Renz (1940b), p. 178; pl. 4, figs. 14a–c.
1948 *Wellerella elegans* BRANSON, Geol. Soc. America Mem. 26, p. 556.

Description.—Shell small, subtriangular in outline, wider than long, and bears three plications on fold and two in sinus. Ventral valve relatively flat, moderately convex over umbo and sub-concave between umbo and lateral margin. Ventral beak acutely pointed with an oval foramen at its apex. Ventral sinus severe and begins one-third the distance from posterior toward anterior margin. Two rather broad plications in sinus and three plications on lateral portions of shell. Lateral and medial plications extend posteriorly one-half length of shell. Plications in sinus twice width of those on lateral edges of specimen studied; lateral plications more rounded on top and attain greater height.

Dorsal valve moderately convex but ventral bending of lateral portions and accentuated dorsal fold give a strongly convex appearance. Dorsal fold bears three small, sharp plications more pronounced than those present on ventral sinus. Lateral portions of valve bear three plications; width of each approximately those on fold. Dorsal lateral

plications less distinct than those on lateral portions of ventral valve.

Internally, ventral valve reveals two vertical deltidial plates extending from floor of valve to support two well-developed teeth.

Dorsal interior bears short, low, median septum, which supports an undivided hinge-plate. Attached to anterior extremities of hinge-plate are two vertically curved crura. Only one specimen revealed dorsal interior, but its crushed condition does not reveal the exact construction of the septum-hinge-plate junction.

Discussion.—The genus *Wellerella* Dunbar and Condra 1932 was established to include a group of Pennsylvanian species previously referred to *Pugnax*. It is distinguished from *Pugnax* on the basis of internal characters. *Pugnax* has a divided dorsal hinge-plate and lacks a median septum.

> The genera *Camarotoechia*, *Wilsonia*, *Leiorhynchus*, *Paraphorhynchus*, *Pugnoides*, and *Hemiplethorhynchus* are somewhat similar externally but all are distinguished by having a divided dorsal hinge-plate and a small crural cavity above the median septum. (Dunbar and Condra, 1932).

Using these criteria, Branson chooses to refer King's *Pugnoides elegans* to *Wellerella* (Branson, 1948).

The most distinguishing morphologic features of the shell are its severe sulcus which forms a gap in the anterior margin when viewed in a ventrodorsal direction and the sharp convergence of the ventral sulcus when viewed in longitudinal profile. The marked difference in the strength and width of the lirae on the ventral sulcus and the dorsal fold are distinctive in this species.

The shell's spreading triangular shape, and two broad lirae in the ventral sinus and three fine lirae on the dorsal fold distinguish the species from *Wellerella swalloviana*.

Occurrence.—The species *Wellerella elegans* has been reported from the Hess, Leonard, and Word formations of the Glass Mountains (King, 1931), and the upper Hueco limestone at Sierra Diablo. Affinitives also occur in specimens from the Lower Permo-Carboniferous of the Caracorum Range. The Rustler species occurs in the lower siltstone and dolomite of the lower member at localities Nos. 55-1, 55-4, and 55-16, and in the lower siltstone at U. S. Coast and Geodetic Survey's triangulation station "Harral" (Harral quadrangle, fig. 2).

Genus COMPOSITA Brown 1890
COMPOSITA cf. C. GUADALUPENSIS (Girty)
Plate 71, figures 9–11, 13

1909 *Composita mexicana* var. *guadalupensis* GIRTY, U. S. Geol. Survey Prof. Paper 58, p. 390, pl. 24, figs. 11–13b.
1931 *Composita mexicana* (Hall), KING, Univ. Texas Bull. 3042, p. 129.
1941 *Composita guadalupensis* (Girty), STAINBROOK & MADERA, Jour. Paleontology, vol. 15, p. 381, pl. 55, figs. 19–21.

Description.—Shells small, biconvex, subovate in outline, with rounded anterolateral and posterolateral margins. Immature shells subcircular in outline and strongly biconvex but anterior and anterolateral growth results in a subovate shell at maturity, with greatest width at midlength. Some information about ontogeny is available: growth lines readily distinguishable on larger shells. Diminishing anterior growth, accompanied by ventrodorsal bending of shell at maturity, results in a low dorsal fold and shallow ventral sulcus. Anterior margin of shell slightly truncated.

Rounded beak of ventral valve bears small oval foramen. Ventral valve arched, point of greatest convexity slightly posterior to midlength. From midpoint to anterior margin curvature is greater than in a posterior direction, with a slight dorsal bending of anterolateral portions of shell. Shallow mesial sulcus confined to anterior one-third of shell.

Dorsal valve attains about same convexity as ventral valve, arching rapidly anterior of beak. Slope of shell decreases slightly anteriorly, accompanied by a flattening of anterolateral portions to form a medial fold. Both valves marked by concentric lines of growth which become closely spaced at anterior margin.

Incomplete preservation prevents complete understanding of internal morphology, but two well-developed teeth can be observed in the pedicle valve. Dental supports and septa described by Stainbrook and Madera were not observable.

Discussion.—Although Girty's variety *Composita mexicana* var. *guadalupensis* is considered synonymous with *C. mexicana*

Hall by King (1931), Stainbrook and Madera look upon *C. guadalupensis* as a separate species after a comparison of Girty's and Hall's illustrations. The writer supports this differentiation; his shells show close agreement with figures of Girty's variety, and vary from Stainbrook and Madera's description only in the uncertainties of the two ventral septa, which are not present probably owing to poor preservation. One might explain an affinity with *C. mexicana* on the basis that the shells were dwarfed because of the severity of environment; yet if shape relationships and the character of the mesial sulcus were taken as characters of specific importance, they would not support such a hypothesis.

Using these criteria in comparing *C. subtilita* and *C. arizonica*, the Kaibab species, the stronger fold and sulcus of *C. subtilita* should distinguish the two forms.

Occurrence.—In the dolomite lens in the lower member of the Rustler at localities Nos. 55-1 and 55-16.

PRODUCTUS? sp.
Plate 71, figure 4

Description.—Shells small, strongly inflated, and approximately 16 mm long. Ventral valve irregularly curved longitudinally, tumid, and of greater width than length. Umbonal regional too poorly preserved to distinguish presence of fine reticulation, but flattened posterior is apparent. A slight geniculation marks beginning of uniformly curved anterior portion of shell. Transversely, valve regularly curved, slightly flattened medially, and bears mesial sinus. Deep narrow sinus begins near umbo and extends to anterior margin. The coarse, irregular radial ribs bear spines that have no definite pattern, but external casts exhibit very meager evidence of spine insertions.

Dorsal valve and internal characters of this species are not known to writer.

Dimensions of two specimens are as follows:

Length, straight line	15 mm ±
Length, curve	—
Width	20 mm ±
Thickness	7 mm

Discussion.—The spirally enrolled form, the coarse radial ornamentation and medial sinus are well developed in the Rustler shell, yet neither of these morphologic features is of taxonomic importance.

Occurrence.—In the lower siltstone of localities Nos. 2 and 3 and in the lower dolomite of locality No. 1.

Class PELECYPODA
Genus PLEUROPHORUS
PLEUROPHORUS LUNULUS Walter, n. sp.
Plate 72, figures 9, 12

Description.—Relatively flat, biconvex shell with a low indistinct umbonal fold extending posteriorly to midpoint of posterior margin thus accentuating convexity in this area. Posteroventral sulcus indistinct or absent with no lobation of shell. Hinge-line elongate and straight, slight ventral bending in anterior part. Entire surface of valve bears numerous distinct (both fine and coarse) concentric growth lines; no radial costellae present. Distinctive posterior margin extends obliquely ventrad, curving sharply anteroventrad below midpoint. Anterior margin almost evenly curved, with greatest convexity at midpoint.

Dentition of left valve: one cardinal and one lateral tooth. Narrow, elongate-triangular cardinal tooth just behind the beak with apex directed toward it. Margin of tooth and overlying socket slightly convex-dorsad. Socket of same shape as cardinal tooth but more elongate; its upper margin approximately parallel to dorsal margin.

Below cardinal tooth an ovoid depression is separated from anterior adductor impression by an elevated ridge extending from posterior extremity of cardinal tooth to midpoint of anterior margin. Narrow posterior lateral tooth extends to within one-quarter shell length anterior to posterior margin trending slightly posteroventrad to form a wedge-shaped furrow between hingeline and lateral tooth.

Anterior adductor muscle impression ovoid and separated from main visceral cavity by an elevated buttress inclined anteriorly and directed toward beak. Impression under beak ventrad of the midlength. Posterior adductor scar and pallial line unknown, but lunule and escutcheon well defined. Dimensions of shell: height, 5 mm; length, 12.5 mm; maximum convexity of left valve, 2 mm.

Discussion.—The shells described are

fragmentary, exhibiting only the beak area of the species with the exception of one specimen of a left valve which is completely preserved. The valve has approximately the same dimensions of *Pleurophorus albequus* Beede, but internal characters resemble *P. costatus* (Brown) illustrated by Newell (1940 pl. 3, figs. 9–13). The outline of the shell closely resembles that of *P. albequus longus* Beede, but the anterior margin of the shell from the Rustler is more symmetrical, less angular, and it possesses a straighter hingeline. The most characteristic morphologic features are the low indistinct or absent umbonal fold, distinct form of the posterior margin, absence of radial costellae, nearly semicircular anterior margin, and the flattened, elongate cardinal tooth and socket. *P. subovalis* Waagen (1881) from the Upper Productus limestone of India has the same proportions as this species and bears close comparison; its dimensions are: length, 44 mm; height, 18 mm; thickness of left valve, 8 mm; apical angle, 150°.

Occurrence.—The Indian shell was found in a "very hard, compact limestone" at Khura at the upper limit of the Middle Productus limestone and in a "hard, somewhat oolitic limestone" in the lower beds of the Upper Productus limestone at Chidru. The Rustler species is common in the dolomite of the lower member at locality No. 55-1.

PLEUROPHORUS sp. (a)
Plate 72, figure 13

Description.—Fragmentary shell exhibiting only dentition and a portion of anterior shell; inferred dimensions: length, 48.5 mm; height, 18 mm; convexity of right valve, 7 mm. Faint growth lines distinguished on poorly preserved shell, scant and incomplete. Dentition of shell definitely that of genus *Pleurophorus* and resembles that of *P. albequus*. Large size of shell, near semicircular anterior margin, and increased elevation of posterior lateral tooth are most distinctive morphologic features of this probably new species. Additional material is needed to establish its identity.

Occurrence.—Only one fragmentary right valve of the species was found in the dolomite of the lower Rustler member at locality No. 55-1.

PLEUROPHORUS sp. (b)
Plate 70, figure 2

Description.—Shells moderately elongate, of average convexity. Anterior half of shell has a greater convexity than posterior; however, anterior convexity does not reach proportions of an umbonal fold. Postero-ventrad sulcus indistinct or absent. No surface ornamentation observed on specimen. Extraneous material and granular texture of replacing material obscure external ornamentation. Dorsal margin slightly oblique to ventral margin with a moderate ventrad bending anteriorly approaching beak. Prominent beak accented by abrupt indentation in dorsal margin, whence it continues anteroventrad to anterior margin. Anterior margin sharply curved anterodorsad, becoming more gently curved approaching ventral margin.

Dentition of left valve: one cardinal tooth and one lateral tooth. Elongate triangular cardinal, straight, and apex is directed posteriorly. Anterior portion of tooth more pronounced, and situated immediately below beak. Upper margin of tooth and overlying socket straight and horizontal. Triangular socket very slightly curved dorsad with apex directed anteriorly. Narrow lateral tooth extends posteriorly within one-fourth shell length in front of posterior margin of shell with a slight posteroventrad trend, to form wedge-shaped furrow between hingeline and lateral tooth at posterior extremity.

Anterior adductor muscle scar ovoid and separated from main visceral cavity by an elevated buttress inclined anteriorly to form approximately a 60° angle with horizontal. Anterior adductor muscle scar slightly anterior of beak and at midwidth of shell. Main visceral cavity ovoid with greatest depth in anterior one-third of shell. Posterior adductor scar and pallial line unknown.

Dimensions as follows: height, 2.3 mm; length, 5.1 mm; approximate convexity of left valve, 0.8 mm.

Discussion.—Except for the well-defined posteroventrad sulcus and radial costellae, absent in this specimen, the species has a striking similarity to *P. albequus*. Except for these disparities the writer would prefer such a designation, but until better material

is available for study it shall be designated *Pleurophorus* sp. (b).

Occurrence.—Although complete specimens are rare, fragments of the shells exhibiting the structure of the hingeline and dental area are abundant in the limestone of the lower member. Specimens have been collected from localities Nos. 55-9, 55-17, 55-18, and 55-21.

Genus DOZIERELLA Newell 1940

DOZIERELLA aff. D. GOULDII (Beede)
Plate 72, figure 7

Description.—An external cast of a small pteriacid, moderately convex, noncostate. Auricles short and well defined, posterior auricle approximately twice length of anterior auricle. Posterior portion extends approximately one-third shell length behind posterior extremity of hingeline.

Beak acute (80°), relatively convex, extending over hingeline; approximately one-fifth shell length behind anterior margin. Spreading umbonal fold extends obliquely from hingeline at an angle of 60°, bounded on each side by a sulcate flattening of shell boundaries.

Right valve and internal character of shell unknown. Left valve has the following dimensions:

Length of shell	9.5 mm
Height of shell	5.0 mm
Length of hingeline	6.0 mm

The surface of valve is marked by very fine indistinct concentric growth lines, which become more prominent over umbonal fold.

Discussion.—The specimen resembles *Dozierella gouldii* (Beede) Newell 1940, but the angle formed by the bisectrix of the umbonal fold and hingeline (80°) is somewhat greater than *D. gouldii* Newell (p. 284, pl. 1, fig. 14) giving less obliquity to the Rustler species. According to Newell, *D. gouldii* is the most abundant species in the Custer fauna; nevertheless, he found some variation in the large collection studied. The few specimens at hand allow only a tentative designation of *D. gouldii*, pending further study of additional material.

Occurrence.—*Dozierella gouldii* (Beede) is reportedly abundant wherever fossils are found in the Whitehorse sandstone of Oklahoma and Texas, and also occurs in the Azotea tongue of the Carlsbad limestone (at the top of the Seven Rivers formation in southeastern New Mexico). The specimens here described were found in the dolomite of the lower member at locality No. 55-1, and in the limestone of the lower member at locality No. 55-21.

Genus ALLORISMA

ALLORISMA aff. A. DUBIUM Waagen
Plate 72, figure 3

1881 *Allorisma dubium* WAAGEN, Palaeontologica Indica, Mem. Geol. Survey India, ser. 13, vol. 1, pt. 3, p. 196, pl. 17, figs. 7a, b.

Description.—Small, biconvex, elongate-oval external casts with a length approximately twice greatest width. Posterior margin high, obliquely curved from hingeline to midlength where it curves subangularly and obliquely forward. Ventral margin evenly rounded and convex as far as beak; it curves upward toward hingeline to form a not quite semicircular anterior margin. Beak low, rounded, incurved to hingeline with spreading umbonal fold that forms an apical angle of 120° and slopes gently anteroventrad to reach maximum convexity at midpoint. From this point to ventral margin the curvature of the shell increases. Posterior margin curves gently to dorsal margin making a sharp turn dorsoanteriorly at midpoint continuing with a dorsal convexity above hingeline, whence it slopes ventrad to dorsal margin. Posterior portion of valve flat; disappearance of umbonal fold in front of rear margin produces a spatulate posterior portion of valve.

Entire surface of valve bears distinct growth lines interspaced by finer concentric striae. Ontogeny of shell indicates a uniform growth elongating posteriorly as shell approaches maturity.

Internal character of shell unknown, but dimensions are as follows:

	1 (left valve)	2 (right valve)
Length of shell	10.5 mm	18.5 mm
Height of shell (max.)	5.5 mm	8.2 mm
Convexity of single valve	1.8 mm	2.8 mm
Apical angle (approx.)	120°	120°

Discussion.—The outline of the shells resembles that of *Allorisma dubium* Waagen

which has the following dimensions:

Length of shell	21 mm
Height of shell	10 mm
Thickness of single valve	5 mm
Apical angle	135°

Waagen (1881) stated of *A. dubium*,

> Of all the genera hitherto described, it can be most probably attributed to the genus *Allorisma*, though the well-developed area does not agree very well with that genus.

The American and Indian shells are alike except that the posterior portion of the Indian shell is slightly less convex. The interrelations of the two valves of the American shell cannot be observed, and the posterodorsal curve of the dorsal margin is different from that of *Allorisma*. Thus although the writer has not definitely assigned the species to this genus, the American shell is in close agreement with the Indian shell designated *A. dubium* by Waagen (pl. 17, figs. 7a, b), and so far as the writer knows, Waagen's designation is undisputed. The distinctive posterior outline of the shell distinguishes the species from other species of *Allorisma*.

Occurrence.—*Allorisma dubium* Waagen was found in a "friable sandstone" in the middle of the Upper Productus limestone in the Salt Range of India. Three specimens were collected from the siltstone of the lower Rustler member, two at locality No. 55–3, one at locality No. 55–4, and one at locality No. 55–6.

Genus NUCULOPSIS (Walcott) Schenck 1939
NUCULOPSIS (PALAEONUCULA?) aff. N. OKAWENSIS Schenck
Plate 73, figures 9, 10

Description.—Specimens very small, bivalved, subtrigonal shells, approximately 2 mm long. Dorsal margin gently rounded, flattened in front of beaks, but ventral margin strongly curved. Curvature increases anteriorly to form a narrowly curved anterior margin. Posterior margin relatively straight; its junction with dorsal margin forms a right angle; an acute angle in some specimens is formed by the junction. Angle formed by the dorsal and posterior margins governed somewhat by width of umbone. Faint ligamental groove present along hinge margin. Taxodont dentition obscured by poor preservation, but nine posterior and four to six anterior teeth distinguished. Shell strongly convex with point of greatest convexity at midlength in front of peak. Surface ornamentation indistinct or absent; two to three very faint growth lines near ventral margin. Dentition of shells not known.

Discussion.—The specimens are very similar to those of "*Nucula*" *levatiformis* Walcott illustrated by Girty (1909, pl. 10, figs. 7–8). Schenck (1939) states that "*Nucula*" *levatiformis* Walcott is insufficiently diagnosed to permit a generic assignment, but believes the species may be a "nuculid, related to *Nuculopsis okawensis* Schenck." A comparison of the Rustler species with illustrations of *N. okawensis* Schenck shows that the Rustler shell is much smaller and possesses a more sharply curved anterior margin. Ornamentation is not sufficiently preserved on the Rustler shell to permit a comparison.

Occurrence.—This species is abundant in the gray limestone of the lower Rustler member; it occurs with the gastropod fauna. Specimens have been collected at localities No. 55–12, 55–3, 55–9, 55–17, and 55–21.

Genus ACANTHOPECTEN
ACANTHOPECTEN COLORADOENSIS (Newberry) Newell 1937
Plate 72, figure 14

1861 *Pecten coloradoensis* NEWBERRY, Geol. Rept., U. S., 36th Congress, 1st Sess., Senate Exec. Document and House Exec. Document No. 90, pt. 3, pp. 1–154.
1936 *Acanthopecten coloradoensis* (Newberry). STOYANOW, Geol. Soc. America Bull., vol. 47, p. 498.
1937 *Acanthopecten coloradoensis* (Newberry). NEWELL, Kansas State Geol. Survey, vol. 10, p. 75, pl. 12, figs. 7a, b, 13, 14, 15a, b.
1938 *Acanthopecten coloradoensis* (Newberry). MCKEE, Carnegie Inst., Pub. 492, pp. 161–162.
1944 *Acanthopecten coloradoensis* (Newberry). NEWELL, in Shimer and Shrock, Index Fossils of North America, p. 445, pl. 159, fig. 5.
1948 *Acanthopecten coloradoensis* (Newberry). BRANSON, Geol. Soc. America Mem. 26, p. 559.

Description.—Specimens large, biconvex shells bearing numerous relatively large costae on moderately convex exterior. On

dorsal portion of shell costae closely spaced diverging ventrally to a density of three costae per cm at ventral margin. Newell (1937) reports 23 costae on a nearly complete hypotype.

Fila crossing costae and interspaces not easily distinguished on all portions of shell owing to poor preservation, but appear more prominent and closely spaced dorsoanteriorly. Fila occupying ventral third of the shell relatively straight, but those on dorsal portion ventrally curved, pointed in interspaces, and more severely arched on costae. This trend increases in a ventral direction until fila resemble edges of imbricating lamellae. Fila less pronounced and moderately curved on anterior and posterior portions of shell. Spreading umbonal fold nearly uniform in curvature with a flattening of anterior and posterior areas.

Discussion.—The specimens here described are an incomplete external cast and external mold. The structure of the beak and hingeline could not be observed on the specimens at hand. Although no dimensions are available, the diagnostic ornamentation of the specimens leaves little doubt as to their identity. A comparison of the specimens with those illustrated by Newell (1937, pl. 12, figs. 7a, b, 13, 15, 15a, b), with due regard for the preservation of the Rustler forms, shows a striking agreement in the two shells.

Occurrence.—The Rustler formation contains the highest occurrence of *Acanthopecten coloradoensis* recorded to date. The species was found in the dolomite of the lower member at locality No. 55-1. *A. coloradoensis* has been reported from the limestone of the Kaibab formation in northwestern Arizona, from Las Vegas quadrangle, Nevada, and from the Word formation of the Glass Mountains.

Genus AVICULOPINNA Meek 1864

AVICULOPINNA sp.
Plate 73, figure 1

Description.—Shell elongate, biconvex, with an apical angle of 20° and a posterior margin not quite semicircular in outline. Posterior margin greatly curved, oblique to hingeline, increasing its ventroanterior curvature below midpoint. Only posterior portion of shell exposed; hard dolomite matrix could not be removed without injuring shell. Exposed surface bears numerous, very fine, concentric lirae which parallel posterior margin, increasing their anterior curvature and becoming more closely spaced ventrad. Average width of interspaces approximately four times that of lirae. No apparent thickening of dorsal margin. Inferred length of shell, assuming a uniform convergence of dorsal and ventral margins, is 40 mm. Character of anterior margin and location of beak unknown; however, no exposed features justify a reference to *Pinna*.

Occurrence.—One specimen retaining its original shell material was collected from the dolomite in the lower member of the Rustler at locality No. 55-1.

Class GASTROPODA

Genus EUPHEMITES

EUPHEMITES CIRCUMCOSTATUS Walter, n. sp.
Plate 73, figures 20, 21, 23, 24

Description.—Specimens small to medium, globose, planospiral, convolute gastropods; height slightly less than breadth. Whorls slightly depressed, rounded, bearing conspicuous spiraled costae well developed on the parietal inductura. Bilobed dorsal lip, expanded at sides, split by a narrow sinus forming an angular notch at dorsum. Dorsal margin gently curved into median insinuation.

Ventral lip covered by narrow, rounded, revolving costae which extend out on outer whorl about two-thirds distance to margin of dorsal lip; beyond, costae continue as small nodes to within one-twelfth whorl circumference of dorsal extremity. Lateral costae, shorter than medial costae, begin their nodal habit at a greater distance from dorsal margin. Eight costae divided by a medial furrow or selenizone narrower than those on either side. Medial furrow referred to as a selenizone; no growth lines can be distinguished. Approaching umbilical region costae decrease in height and width. Between last lateral costae and umbilical region a series of nodes extends from axis to half distance to margin of dorsal lip (Pl. 73, fig. 21).

Dimensions as follows:

Length of shell.....	7.5 mm	12.5 mm
Width of shell.....	8.5 mm	13.5 mm
Height of aperture.....	2.0 mm	3.0 mm

Discussion.—The shells studied were incomplete and fragmentary. Only one specimen showed the shape of the aperture and median insinuation in the dorsal lip. The writer knows of no other species which closely compares with the Rustler form. *Euphemites apertus* (Waagen) from the "topmost beds" of the Upper Productus limestone, India, is similar in size and shape to the Rustler shell but the two sharp peripheral carinae and the greater glabrous portion of the outer whorl are pronounced differences observed in the Indian shell. The only known American species to which the shell could be compared is *Euphemites subpapillosus* White.

The spiraled costae or ribs do not terminate in the aperture, but have been observed on the surface of the enveloped volutions of broken specimens retaining their same number and distribution. The small number, wide spacing and greater extension of the revolving ribs, plus their nodose habit near the outer lip and umbilical region are distinctive of this new Rustler species.

Occurrence.—This distinctive form is the most abundant and persistent species in the gray thin-bedded limestone of the lower member of the Rustler. Specimens have been collected throughout the area, but are particularly abundant at localities Nos. 55-3, 55-6, 55-9, 55-17, and 55-21. One specimen was collected from the dolomite bed at locality No. 55-12.

EUPHEMITES sp. (a)
Plate 70, figure 10

Description.—Specimen small to medium, globose, planospiral, convolute gastropods; height slightly less than breadth. Whorls slightly depressed, rounded, similar in outline to *E. circumcostatus* Walter, n. sp., but bearing 12 spiraled costae. Dorsal lip and parietal inductura not present.

Twelve very fine, uniform, rounded, equally spaced, revolving costae ornament the enveloped whorls. Two lateral costae less pronounced than medial costae. No nodes observed on the interwhorls, ornamentation of outer whorls unknown. Selenizone or medial insinuation cannot be distinguished; growth lines absent.

Dimensions as follows:

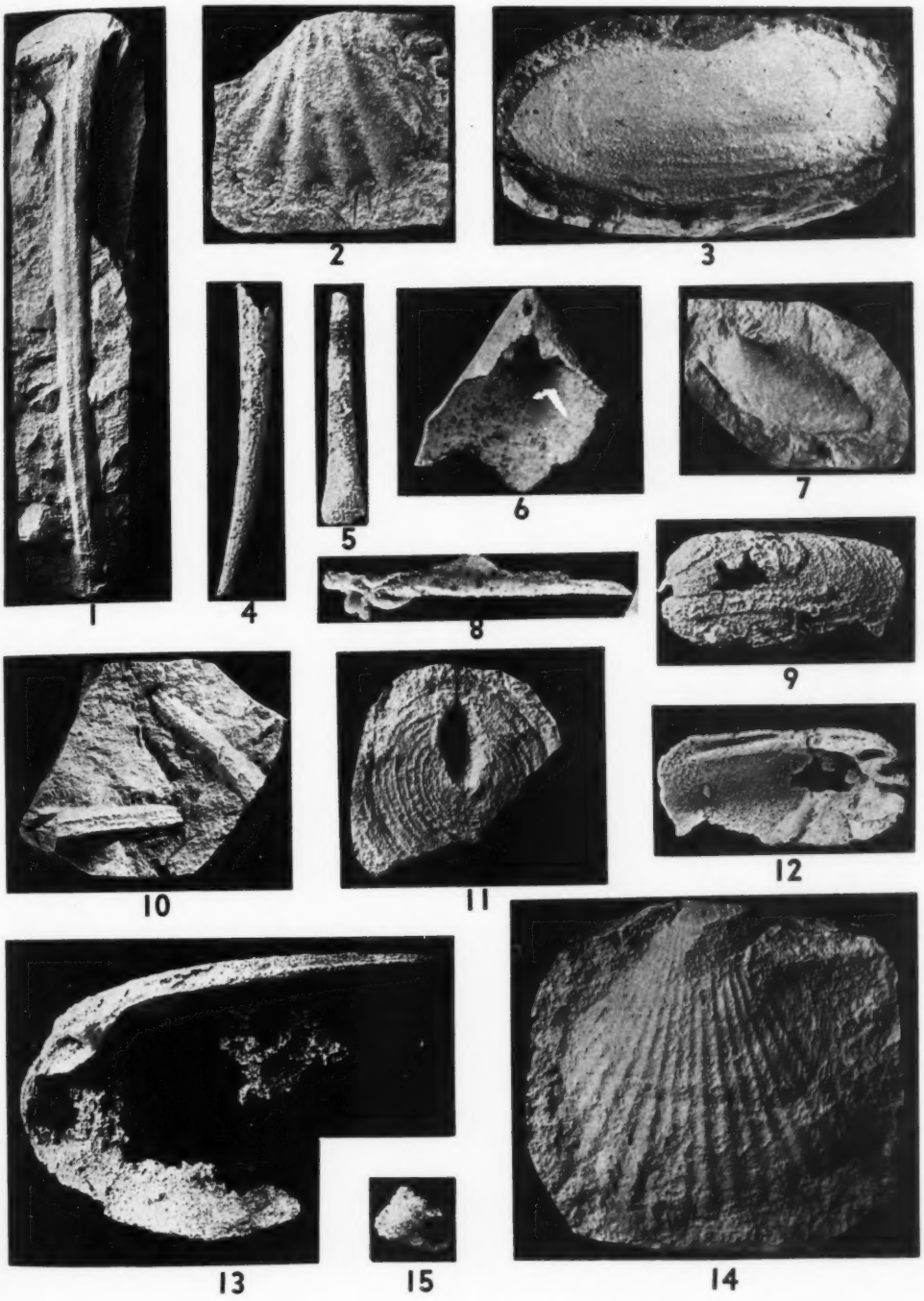
Length of shell	incomplete
Width of shell	8.0 mm
Height of aperture	incomplete

Discussion.—This species is almost identical to *E. circumcostatus* Walter n. sp.; however, the finer, more numerous spiraled costae make it distinctive. A study of more complete specimens will probably determine this species to be new, but the writer hesitates to make such an assignment until the structure of the aperture and morphology of the outer whorl have been determined.

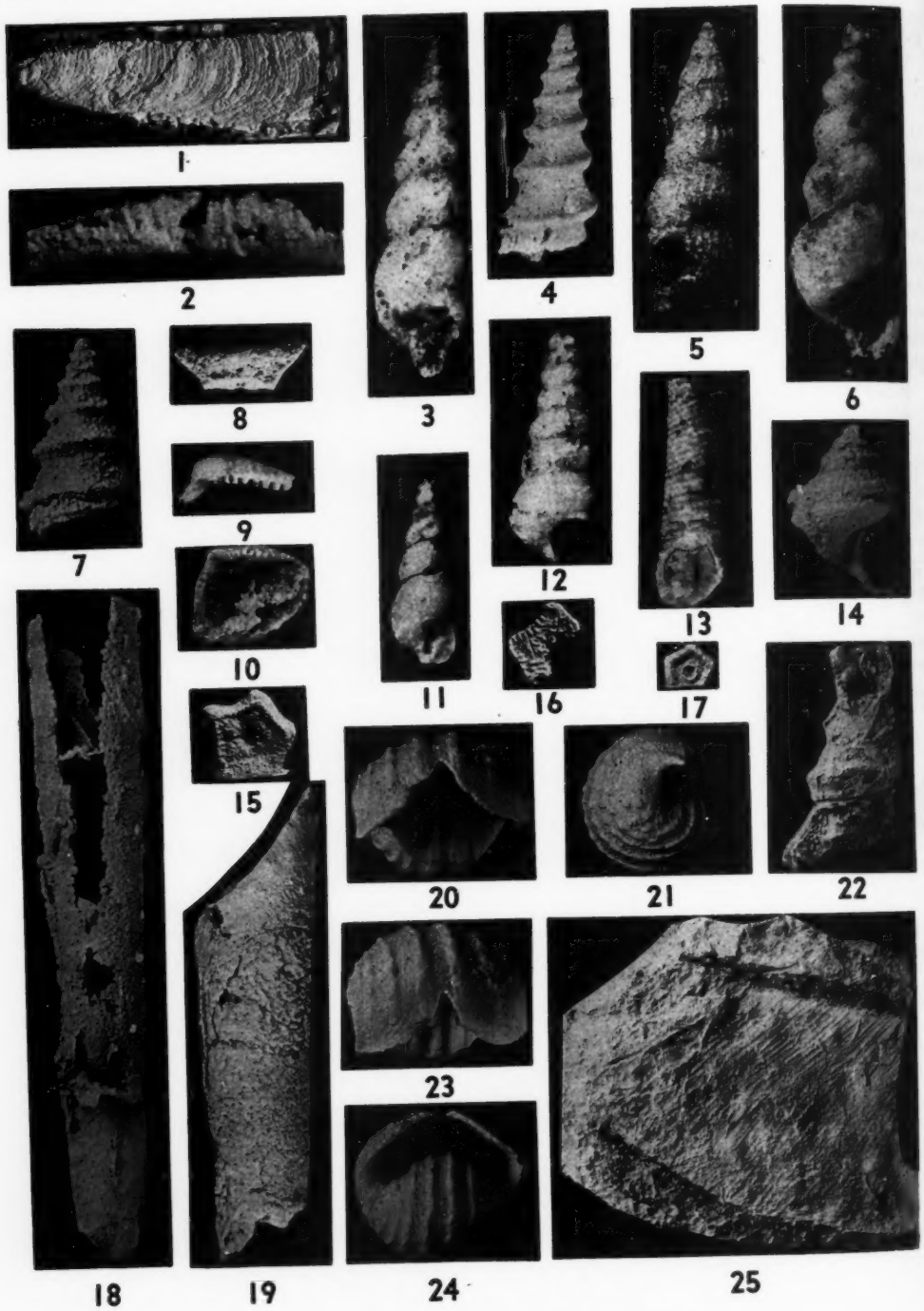
Occurrence.—A single fragmentary specimen was collected from the base of the lime-

EXPLANATION OF PLATE 72

FIGS. *1, 10*—Plant fragments, showing octagonal faceting, ×1. (p. 684)
2—*Hustedia* cf. *H. meekana*, external cast of ventral valve ×3. (p. 701)
3—*Allorisma* aff. *A. dubium*, external cast of a right valve ×3. (p. 693)
4—*Dentalium* sp. ×3. (p. 700)
5—Echinoid spine ×3. (p. 701)
6—*Wellerella elegans* (Girty). Ventral interior showing well-developed teeth and oval foramen ×3. (p. 689)
7—*Dozierella* aff. *D. gouldii*. External cast of the left valve ×3. (p. 693)
8—*Schizodus* sp. Oblique ventral view of dentition of a right valve ×5. (p. 686)
9, 12—*Pleurophorus lunulus* Walter n. sp., holotype *9*, exterior of left valve showing obliquity of the posterior margin, as determined from growth lines, posterior margin incomplete ×3; *12*, interior of same specimen; note large lunular cavity and divergence of hingeline and posterolateral tooth, and deep anterior adductor muscle cavity ×3. The deposit in the center of valve is Alvar. (p. 691)
11—*Orbiculoidea* sp. Mold of ventral valve ×4. (p. 701)
13—*Pleurophorus* sp. (a). Fragment of right valve, large lateral tooth ×2. (p. 692)
14—*Acanthopecten coloradoensis* (Newberry). External cast exhibiting arched fila ×1. (p. 694)
15—Trochiform gastropod ×10. (p. 702)



Walter, Permian (Rustler) fossils, Texas



Walter, Permian (Rustler) fossils, Texas

stone in the lower member of the Rustler formation at locality No. 55–21.

GONIASMA sp.
Plate 73, figure 4

Description.—High-spired shells of medium size, fractured anteriorly so that aperture and base of shell unknown. Whorl profile similar to that of Murchisoniidae, inclined from upper suture at an angle of approximately 25° from vertical, rounding outward to a strongly elevated selenizone-bearing carina. Below carina, profile slopes sharply inward to lower suture at a slightly greater angle than slope above carina.

Selenizone slightly concave, narrow and bounded on each side by two fine, distinct, revolving costae. Selenizone-bearing carina situated low on periphery of whorl in lower edge of carina. Seemingly two lower sutures present; lower of two covered by succeeding whorl, but observed in broken shells. Growth lines and ornamentation obscure or absent, but faint revolving lirae exist near upper suture. Protoconch faint and obscure, and first three whorls show very little angularity; carina not well developed until fourth whorl.

Dimensions of fragments of shells are as follows:

	(6 whorls)	(8 whorls)
Height of shell.....	5.0 mm	7.8 mm
Width of whorl (max.).	2.8 mm	3.5 mm
Pleural angle.....	22°	22°

Discussion.—The shells are moderately well preserved, exhibiting faint ornamentation, but the critical apertural margin and other basic characters of taxonomic importance are not fully known. A shell of very similar size and whorl profile is illustrated by Girty (1909, pl. 29, fig. 20), but he was uncertain of the specific identity. The Rustler shell appears to be better preserved and is more suitable for identification but the writer prefers to wait until better material is available. *Murchisonia conjungens* Waagen, the Indian shell from the top beds of the Upper Productus limestone, bears comparison.

Occurrence.—Specimens are common in both the gray limestone and the lower dolomite of the lower Rustler member at localities Nos. 55-1, 55-13, 55-17, 55-21, and in the dolomitic limestone of member N at locality No. 55-8.

Genus MURCHISONIA d'Archiac & de Verneuil, 1841
MURCHISONIA? cf. M. GOULDII Beede
Plate 73, figure 7

1907 *Murchisonia gouldii* BEEDE, Kansas Univ. Sci. Bull., vol. 4, p. 167, pl. 8, fig. 6.
1907 *Murchisonia collingsworthensis* BEEDE, Kansas Univ. Sci. Bull., vol. 4, p. 166, pl. 8, figs. 7, 7a.
1907 *Orthonema ? texana* BEEDE, Kansas Univ. Sci. Bull., vol. 4, p. 168, pl. 8, figs. 5, 5a.
1940 *Murchisonia gouldii* (Beede) NEWELL, Geol. Soc. America Bull., vol. 51, pp. 306–

EXPLANATION OF PLATE 73

FIG. *1*—*Aviculopinna* sp. Left valve ×1. (p. 695)
2, 6, 13—*Plagioglypta ? annulistriata* (Meek and Worthen); ×10. (p. 700)
3, 11—*Streptacis ?* cf. *S. permiana* (Beede) Knight. *3*, ×10; *11*, specimen showing outline of outer lip and tilted nuclear whorl ×10. (p. 699)
4—*Goniasma* sp. ×5. (p. 697)
5—*Paleostylus* (*Pseudozygopleura*) sp. Specimen exhibiting sinuate transverse costae, and adpressed whorls ×10. (p. 698)
7—*Murchisonia ?* cf. *M. gouldii* ×10. (p. 697)
8, 15–17—Crinoidea. *8*, Crinoid plate ×3; *15, 16*, Pentagonocyclopa ×3; *17*, Pentagonocyclopa, showing rimmed lumen and crenulate margin ×5. (p. 701)
9—Nuculid. Fragment of beak area bearing part of dentition ×10. (p. 694)
10—*Nuculopsis* (*Palaeonucula ?*) aff. *N. okawensis*. View of right valve interior ×10. (p. 694)
12—Loxonematoid gastropod, revolving ornamentation not clearly visible ×10. (p. 702)
14—*Worthenia ?* sp. Note revolving ornamentation ×10. (p. 699)
18, 19—*Plagioglypta ? canna* (White). *19*, specimen exhibiting a truncated posterior ×2. (p. 700)
20, 21, 23, 24—*Euphemites circumcostatus* Walter n. sp. *20*, profile view of outer lip; *21*, lateral view showing nodose umbilical area; *23*, view showing median insinuation in dorsal margin and nodose habit of revolving costae near dorsal margin; *24*, apertural view of crushed specimens ×4. (p. 695)
22—Gastropod ×10. (p. 701)
25—*Pinna ?* sp. ×1. (p. 695)

309, pl. 5, figs. 1–14, pl. 6, fig. 1a–e.
1942 *Murchisonia gouldii* (Beede) CLIFTON, Jour. Paleontology, vol. 16, p. 694, pl. 101, fig. 29.
1944 *Murchisonia gouldii* (Beede) NEWELL in Shimer and Shrock, Index Fossils of North America, p. 459, pl. 186, figs. 6–8.
1948 *Murchisonia gouldii* (Beede) BRANSON, Geol. Soc. America Mem. 26, p. 712.

Description.—Species characterized as "high spired gastropods of ten to twelve whorls when mature, with a wide shallow sinus in outer lip culminating on a rounded carina in a seemingly short slit that gives rise to a selenizone" (Knight, 1940). These morphologic features unobserved on Rustler shells either because of poor preservation or immature shells. Shells possess a distinct, elevated selenizone, and two faint, closely spaced spiral costae at lower suture. Whorl gently shouldered against previous whorl and gently concave from shoulder to selenizone-bearing carina; beyond this point whorl profile concave to two costae at lower suture. Selenizone-bearing carina varies its position from middle to very low on outer surface of whorl (Knight, 1940), latter position more common in Rustler shells.

Base of shells, though incomplete, small, flatly rounded to subconcave, anomphalous, exhibiting a short columella approximately three-fourths height of body whorl, with a slightly calloused and reflected columellar lip. Outer lip unknown. Extremely faint and incomplete growth lines distinguished on lower portion of whorls. Extending below selenizone, they have a strong forward obliquity to lower revolving costae from which point they obtain a moderate forward convexity, and backward obliquity approaching columella.

Selenizone, occupying the strong carina, bounded by two very fine revolving lirae. No other ornamentation distinguished.

Dimensions are:

Height of shell	3.2 mm	1.9 mm	1.8 mm	3.3 mm
Width of shell (max.)	1.3 mm	1.0 mm	1.2 mm	1.3 mm
Pleural angle	28°	30°		

Discussion.—The low position of the selenizone, angularity of the whorls, and faintness of shoulder in the upper portion of the whorl obscures their identity; moreover, the general small size, high angularity, and small number of whorls probably indicates a neanic growth stage.

Occurrence.—*Murchisonia gouldii* has been reported from the Capitan limestone in Winkler County, Texas, and in the Blaine and Dog Creek of Texas and the Whitehorse of Oklahoma. The Rustler shells occur in the upper gray limestone and lower dolomite in the lower member at localities Nos. 55-1, 55-3, 55-9, 55-17, and others.

Genus PALEOSTYLUS Mansuy 1914
Subgenus PSEUDOZYGOPLEURA Knight 1930
PALEOSTYLUS (PSEUDOZYGOPLEURA) sp.
Plate 73, figure 5

Description.—Specimens minute, high-spired, loxonematoid shells with slightly sinuate transverse costae on ephebic whorls. Nuclear whorls are indistinct, but faint, seemingly highly sinuate costae present. Whorl profile adpressed and slightly arcuate. Transgression from highly sinuate costae of nuclear whorls to less sinuous ephebic costae not distinguished.

Base rounded, anomphalous, with columella slightly reflexed. Character of outer lip not fully known, ornamentation unknown, except for prominent, slightly sinuous transverse costae, which obtain a distinct forward obliquity in lower portion of whorl. Costae evenly spaced, rounded, and present on all whorls.

Dimensions are:

Height	4.0 mm	3.5 mm	2.3 mm
Width (max.)	1.5 mm	1.5 mm	1.1 mm
Pleural angle	23°	18°	

Discussion.—Of the three shells assigned to *Paleostylus* (*Pseudozygopleura*) sp. only one retains the nuclear whorls. The costae are faint and their shape cannot be determined, thus any generic assignment is made with reserve. It is most unfortunate that the shells from these young Permian deposits are not sufficiently preserved to exhibit all of their morphologic features, for the information gained in their study might augment Knight's excellent work on this unique group.

Occurrence.—All the specimens of this species were obtained in the dolomite of the lower Rustler member at locality No. 55-1.

Genus STREPTACIS Meek 1871
STREPTACIS ? cf. S. PERMIANA
(Beede) 1907 Knight 1940
Plate 73, figures 3, 11

Description.—Very small, high-spired, many-whorled shells. Whorl profile slightly arched between sutures, shell base rounded and anomphalous. Columellar lip rather strongly arcuate. Aperture not fully known, lower part of outer lip has a rounded tongue-like form. Growth lines indistinct or absent, but presence of numerous faint, very fine revolving lirae distinguishable. Exact number of lirae undetermined, width of the lirae approximately equaling width of interspaces.

Dimensions of average specimens of six whorls from the Rustler and the Whitehorse.

	Rustler sp.	Whitehorse sp.
Height of shell.....	5.2 mm	7.0 mm
Width of shell (max.).....	2.0 mm	2.1 mm
Pleural angle.....	17°	20°

Discussion.—The shells described by Knight (1940) had no distinguishable ornamentation except growth lines. This could be due to poor preservation which failed to reproduce all the details of the ornamentation in the external molds. The growth lines of the Rustler shells are not sufficiently preserved to justify a comparison of the two species, but the nuclear whorls of the Rustler shells are present and have the characteristic form of *Streptacis*. According to Knight, the form of *Streptacis* is so general that it is of little value in correlation; nevertheless, a further study of the Rustler species with supplementary collections will give more information which might improve the value of the shell for stratigraphic use.

Occurrence.—The species is common in the gray limestone of the lower member at localities Nos. 55-17, 55-3, and 55-21.

?Genus WORTHENIA Koninck, 1883
WORTHENIA ? sp.
Plate 73, figure 14

Description.—Small trochiform shells with a shallow, angular slit or notch above periphery of whorl, giving rise to a selenizone. Body-whorl profile slopes flatly from upper suture at an angle of approximately 55° from vertical making a carinate angulation nearly vertical downward to lower suture, whence it makes a sharp rounded curve onto base. Base rounded, nearly flat, and narrowly phaneromphalous. Columellar lip thin, first bending gently toward umbilicus, then swinging sharply outward to outer lip. Form of outer lip not fully known, its probable shape determined from faint growth lines on the outer whorl. Growth lines leave upper boundary with an acute backward obliquity, rounding quickly forward to form a small rounded sinus, adjacent to first peripheral suture whence it curves sharply downward over angulation of the whorl (direction not determined), entering base with a strong forward obliquity rounding backward to obtain a moderately strong forward convexity before entering umbilicus. It must be understood that the above description is based on very faint growth lines, parts of which are indistinguishable, particularly in the critical region of the selenizone; nevertheless, the writer is reasonably assured that the selenizone occupies the outer surface of the whorl shoulder for there is a slight depression adjacent to the suture inside the angulation of the body whorl. No concavity or accentuated bordering of selenizone, can be distinguished. Ornamentation, three to six very fine revolving lirae on upper surface of whorl, three slightly coarser lirae on periphery of whorl, eight to ten revolving lirae on base with numerous fine lirae on umbilical slope.

Dimensions are:

	Average specimen	Maximum specimen
Height of shell.....	5.0 mm	–
Width (body whorl)....	3.6 mm	10.0 mm
Pleural angle.....	73°	–

Angularity of shell decreases posteriorly; neanic whorls low and rounded, and nucleus unknown.

Discussion.—The shells, though numerous, are fragmentary. The material is sufficiently preserved to show the size and shape of the species and faint revolving ornamentation, yet none of the specimens exhibits the complete outline of the outer lip, and growth lines are scant and obscure.

The carina appears to bear crenulations but their presence cannot be definitely established. Until better specimens are avail-

able for study the writer prefers a tentative assignment to *Worthenia*.

Dr. J. Brookes Knight has collected similar specimens probably belonging to the same genus "near the base of the Bone Spring limestone in the Sierra Diablo in the Leonard and in the lower Word of the Glass Mountains," yet the upper limits of these forms have not been definitely established.

Occurrence.—The shells are numerous in the gray limestone of the lower Rustler member, second in numbers only to *Euphemites circumcostatus*. Collections have been made at localities Nos. 55-3, 55-6, 55-17, 55-9, and 55-12, and it occurs less abundantly in the dolomite at locality No. 55-1.

Class SCAPHOPODA
Genus PLAGIOGLYPTA Pilsbry 1898
PLAGIOGLYPTA ? CANNA (White) 1874
Plate 73, figures 18, 19

1874 *Dentalium canna* WHITE, U. S. Geogr. Survey, W. 100th Mer., Preliminary Rept. Inv. Fossils, p. 23.
1877 *Dentalium canna* WHITE, U. S. Geogr. Survey, W. 100th Mer., Rept. Vol. 4, p. 156, pl. 12, figs. 6a, b.
1903 *Plagioglypta canna* GIRTY, U. S. Geol. Survey, Prof. Paper 16, p. 452.
1909 *Plagioglypta canna ?* GIRTY, U. S. Geol. Survey, Prof. Paper 58, p. 450, pl. 23, figs. 11–13.
1909 *Plagioglypta canna* GIRTY, U. S. Geol. Survey, Bull. 389, p. 95, pl. 11, fig. 11.
1910 *Plagioglypta canna* GIRTY, U. S. Geol. Survey, Bull. 436, p. 44, pl. 6, fig. 14.
1916 *Plagioglypta canna* (White), E. BRANSON, Jour. Geology, vol. 24, p. 657, pl. 3, fig. 13.
1930 *Plagioglypta canna* (White), C. BRANSON, Missouri Univ. Studies, vol. 5, no. 2, p. 58, pl. 15, fig. 6.

Description.—Specimens characterized by large, straight, tapered shells 47 mm. long, 8 mm. wide at apertural end, and 3.5 mm. near apex. No surface ornamentation distinguished. A spoon-like truncation noted on posterior extremity of one specimen (Pl. 73, fig. 19). Apical end of shell unknown and surficial striations indistinct or absent.

Occurrence.—*Plagioglypta canna* has been found in the Delaware Mountain group of Texas, in the Phosphoria formation of Idaho and Wyoming, and in the Kaibab of northern Arizona and southern Utah. The specimens at hand were collected from the gray limestone of the lower Rustler member at locality No. 55-17. This species was abundant at locality No. 55-21, with *Euphemites* and *Goniasma* comprising the majority of the fauna.

PLAGIOGLYPTA ? ANNULISTRIATA
(Meek & Worthen)
Plate 73, figures 2, 6, 13

1870 *Dentalium annulostriatum* MEEK & WORTHEN, Acad. Nat. Sci., Philadelphia, Proc., p. 45.
1873 *Dentalium ? annulostriatum* MEEK & WORTHEN, Illinois Geol. Survey, vol. 5, p. 589, pl. 29, fig. 7.
1889 *Dentalium annulostriatum* KEYES, Acad. Nat. Sci., Philadelphia, Proc., p. 234.
1892 *Dentalium annulostriatum* KEYES, Acad. Nat. Sci., Philadelphia, Proc., p. 251.
1903 *Plagioglypta annulistriata* GIRTY, U. S. Geol. Survey, Prof. Paper 16, p. 452.
1915 *Plagioglypta annulistriata* GIRTY, U. S. Geol. Survey, Bull. 544, p. 147, pl. 15, figs. 15–16a.

Description.—Specimens very small, moderately curved, elongate shells with numerous annular lirae. Shells approximately 1 mm in diameter and taper to 0.6 mm near apex. Shells incomplete and apex absent. Fine annular lirae oblique and irregularly bundled on concave surface of shell.

Dimensions of two specimens are:

Length	5.2 mm.	3.5 mm.
Width	1.0 mm.	.6 mm.
Narrow	.06 mm.	.09 mm.
Lirae/mm	8.0	—

Occurrence.—*P. annulistriata* is common in the gray limestone of the lower Rustler member at localities Nos. 55-9, 55-3, 55-1, 55-16, and 55-21. The species is known in the Wewoka formation, Oklahoma.

Genus DENTALIUM Linné 1758
DENTALIUM sp.
Plate 72, figure 4

Description.—Shells small, moderately curved, elongate, approximately 15 mm long, with a maximum diameter of 1.8 mm tapering to 0.8 mm. Shell has 16 to 20 fine, distinct, longitudinal lirae on average specimen.

Occurrence.—This species is common in the dolomite of the lower member of the Rustler at localities Nos. 55-1 and 55-3.

Division CRINOSTYLI Moore
Main Group PENTAGONOSTYLI Moore
Group PENTAGONOCYCLOPAE Moore
Section PENTAGONOCYCLOPA Moore
PENTAGONOCYCLOPA cf. P. DISPAR Moore
Plate 73, figures 15–17

Description.—Columnals, internodals with a definite pentagonal outline, moderately long, length equaling two-fifths greatest width. Each of five sides concave inward, and parallels axis of stem, giving columnal a subpentagonal to stellate appearance. Small subcircular to pentagonal lumen at center of columnal approximately equals one-tenth of width. Central area of articular face smooth and flat with a sharp rim or collar around periphery of lumen. In weathered specimens, collar not present, giving lumen an apparently larger diameter than actually exists. Stellate central area bounded by a row of fine, straight, non-bifurcating crenellae. Crenellae occur in a single row normal to sides of columnal. Crenellae are very regular, not increasing in number by bifurcation or implantation; visible on the angles of the pentagon. Crenellae present increase in length between angles of pentagon.

Measurements of small internodals of *Pentagonocyclopa dispar* Moore: "width of the articulate face (same as width of segment), 3.0 mm; length of segments, 0.42 mm (average) to 0.84" as compared with an average width of 4.9 mm, length 1.8 mm measured on Rustler specimens.

Discussion.—The ossicles resemble columnals of Pentacrinidae but this latter group bears crenellae which form a petaloid pattern on the articular face. Since no close affinity could be established with the Pentacrinidae or other groups except on the basis of its distinct pentagonal outline, Moore's system of classifying crinoid fragments was used (Moore, 1939). This specimen closely resembles *Pentagonocyclopa dispar* Moore, bearing a rimmed lumen and crenellae at the angles of the pentagon. No columnals containing cirri bases have been collected.

Occurrence.—The group-type occurs in the Checkerboard? limestone in southeastern Kansas near the base of the Coffeyville shale, Ochelata group, Missouri series, Pennsylvanian.

This type occurs intermittently in the dolomite lens of the lower member of the Rustler formation, but is found in abundance at locality No. 55-1 with occasional occurrence at locality No. 55-19 (Harral triangulation station).

ADDITIONAL SPECIES REPRESENTED BY FRAGMENTS

Brachiopods

Hustedia cf. *H. meekana* (Shumard) (Pl. 72, fig. 2). External casts of three incomplete brachial valves were found in the siltstone of the lower member at localities Nos. 55-3, 55-4, and 55-6.

Orbiculoidea sp. (Pl. 72, fig. 11). An external cast of a single ventral valve was collected at locality No. 55-4 in the lower siltstone. It is impossible to determine the location and height of the apex from this flattened specimen. The outline is nearly circular, diameter 9.5 mm.; 12 closely arranged concentric lirae are exhibited by the specimen. The pedicle slit gapes, occupying approximately one-third the distance of the shell.

Chonetids. Specimens occurring as molds were found in the lower siltstone of locality No. 55-3.

Marginifera sp. Specimens are numerous at localities Nos. 55-2, 55-3, and 55-4, but are poorly preserved.

Pelecypods

Myalina sp. A single specimen is the external cast of the left valve; the anterior portion of the shell is broken, preventing further classification. The species was found in the siltstone of the lower member of the Rustler formation at localities Nos. 55-1, 55-2, 55-3 and 55-4.

Ostracodes

Bairdia sp. The specimens of *Bairdia* are too granularly replaced to exhibit the specific characters of the genus. The forms were noted in the insoluble residues of the dolomite in the lower member of the Rustler formation at localities Nos. 55-1 and 55-16.

Echinoids

Fragmentary echinoid spines were collected from the dolomite in the lower mem-

ber of the Rustler formation at locality No. 55-1.

Bryozoans?

Poorly preserved, branched forms have been found in the dolomite in the lower member of the Rustler formation at locality No. 55-1. This assignment is only tentative.

Gastropods

Loxonematidae.—Donaldina? sp. (Pl. 73, fig. 12). Very small, high-spired, anomphalous shells with revolving costae; aperture is not present and growth lines are not readily distinguishable. The shells resemble the form of *Donaldina*, but it cannot be determined whether they are heterostrophic. The dimensions are: height, 3.4 mm; width, 0.5 mm; pleural angle, 15.5.°

The species occur in abundance in the gray limestone of the lower member of the Rustler formation at localities Nos. 55-1, 55-3, 55-6, 55-9, 55-12, 55-17, 55-18, and 55-21.

Neritidae.—A single specimen of the family Neritidae is severely worn and incomplete. The shell is phaneromphalous, low-spired, with a form resembling that of *Naticopsis*. The only specimen was collected from the dolomite of the lower member of the Rustler formation at locality No. 55-1.

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SYSTEMATIC POSITION OF THE PELECYPOD *PLIOCARDIA*[1]

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ABSTRACT—*Pliocardia* is a veneroid pelecypod and is probably most closely related to the subfamily Pitarinae of the family Meretrecidae.

INTRODUCTION

DALL (1903, pp. 1304, 1305) described a new species of pelecypod from the Miocene Bowden marl of Jamaica which he called *Anomalocardia bowdeniana*. The description was based on one small right valve which Dall thought was an immature specimen. Dall's description of *Anomalocardia bowdeniana* is as follows:

> Shell small, ovate-trigonal, subrostrate, with a flexuous base behind; beaks rather high, prosogyrate; lunule large, impressed, well defined, but with no defined escutcheon; posterior end pointed, anterior end rounded, base arcuate, rather prominent mesially; surface sculptured with concentric striae with flattish wider interspaces; hinge normal, rather heavy, inner margins entire; pallial sinus small, angular.

In 1925 Woodring (pp. 147, 148), with the study of additional material, created a new genus *Pliocardia* and a new family Pliocardiidae based on *Anomalocardia bowdeniana*. The family Pliocardiidae was placed in the superfamily Isocardiacea (Glossacea) by Woodring. In his discussion of the genus, he stated that *Pliocardia* also resembles *Vesicomya* Dall.

Palmer (1927, p. 376) followed Woodring's conclusion concerning the systematic position of *Pliocardia*.

The monotypic genus *Pliocardia* has been reported from the Bowden marl only, which Woodring has considered late middle Miocene in age or about the equivalent of the Tortonian stage. Some other authorities consider the Bowden marl younger than this.

COMPARATIVE SHELL MORPHOLOGY

Size.—Pliocardia is a small pelecypod. Of the 18 specimens studied, the smallest one is 4.2 mm. long and 3.2 mm. high. The largest specimen is 9.5 mm. long and 7.2 mm. high. The relationship of *Pliocardia* to other pelecypods can not be ascertained by the size of the shell.

Form of the valves.—The outline of the valves is elongate with a somewhat produced posterior end. There is a slight flexure near the posterior end and running parallel to it which is similar to that found in *Anomalocardia* and some species of *Pitar*. The valve outline is much like that of the chionids and pitarines but also bears some resemblance to the glossoids.

Nature of the shell.—Pliocardia has a porcellaneous shell, but this character is found in most pelecypods and is of no value in showing relationship. However, the shell of *Pliocardia* is thick, like that of many of the veneroids and unlike *Vesicomya*, *Glossus*, and *Meiocardia* which have relatively thin shells.

Ornamentation of the shell.—Pliocardia has closely spaced concentric ribs which resemble many veneroids and glossoids. The well-defined lunule of *Pliocardia* is typically veneroid, although *Vesicomya* also has a lunule. On the interior ventral border are some fine discontinuous grooves, like those found in the meretrecid genus *Transennella;* they are not present in *Glossus*, *Meiocardia*, and *Vesicomya* (fig. 1). These grooves are so distinctive that this morphologic character must be given much importance in ascertaining the true relationship of *Pliocardia* to other pelecypods.

Position of the beaks and ligamental area.—The beaks are strongly prosogyrate, and the ligament appears to have been external, resting on nymphae, and lying entirely behind the beaks. This is the case also in the veneroids and glossoids.

The hinge teeth.—In his description of *Anomalocardia bowdeniana*, Dall (1903, p.

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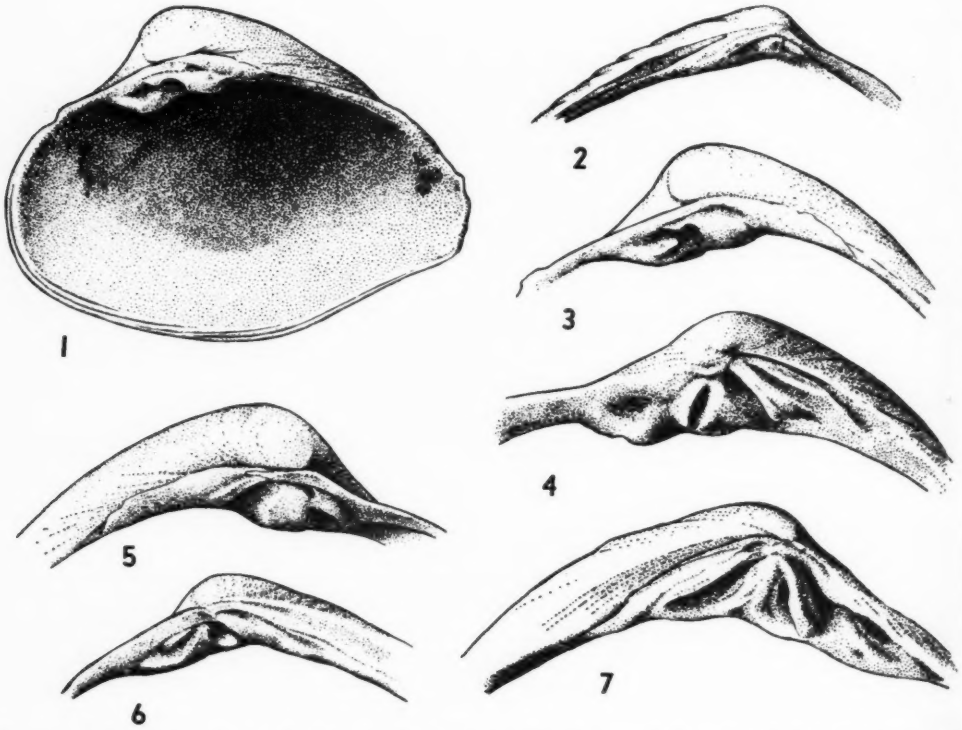
1305) stated that the hinge was normal but rather heavy. Woodring's (1925, pp. 147, 148) interpretation of the hinge teeth was very different. He mentioned no cardinal teeth, but he described two anterior laterals in each valve in some detail. The interpretation was based on the fact that Woodring thought that *Pliocardia* was related to the glossoids.

On careful examination of the left valve I consider the hinge teeth of *Pliocardia* to be much like those of a chionid with but one anomaly—teeth 2a and 2b are joined at the dorsal border. In large specimens these two teeth nearly converge at the dorsal border, and in small specimens (less than 10 mm. long) the two teeth are sometimes joined as in *Chione* (see fig. 2). In the Pitarinae tooth 2a and tooth 2b are joined at the dorsal border, and the tooth shape and arrangement would be even more like *Pliocardia* if the anterior lateral tooth (AII) of the Pitarinae were absent. Tooth 2a in *Pliocardia* is small and arched; tooth 2b is round and massive; tooth 4b is arched, slender, and normal for a veneroid (fig. 5). There are no lateral teeth, and the hinge of the left valve of *Pliocardia* does not resemble the glossoids.

It is the hinge of the right valve of *Pliocardia* which is similar to the glossoids in appearance. Tooth 3b is short and heavy but has an anterior extension which is slender and runs parallel to the dorsal mar-



FIGS. *1, 3, 5*—*Pliocardia bowdeniana* (Dall). Miocene, Bowden marl; Jamaica. *1.* Interior view, right valve showing hinge teeth and discontinuous grooves on ventral border; hypotype USNM 561492. *3.* Hinge teeth, right valve. *5.* Hinge teeth, left valve; hypotype USNM 352829.
2, 6—*Chione grus* (Holmes). Recent; off Cape Hatteras. *2.* Hinge teeth, left valve. *6.* Hinge teeth, right valve; hypotype USNM 44781.
4, 7—*Transennella caloosana* Dall. Pliocene, Caloosahatchee formation; Shell Creek, De Soto County, Florida. *4.* Right valve, hinge teeth; hypotype USNM 561493. *7.* Left valve, hinge teeth; hypotype USNM 561494.
All figures ×10.

gin. This anterior extension is like that seen in some species of *Pitar*. The socket for tooth 2b is large and deep. Anterior to the large socket is a small curved tooth which lies on the ventral border of the hinge plate and is either tooth 1 or the anterior lateral AI. Tooth 3a is apparently missing. If the anterior tooth is 1, the hinge is probably that of a modified chionid; if it is AI, it must be that of a modified meretrecid. The appearance and position of tooth 3a and of the remaining tooth (1 or AI) is more like the meretrecid teeth. Therefore, it is my opinion that the hinge of *Pliocardia* is a highly modified meretrecid one and has the following formula: $\frac{\text{AI, 3b}}{\text{2a, 2b, 4b}}$. Teeth 3a and 1 are crowded in many meretrecines and pitarines (fig. 4).

Adductor muscle scars and pallial line.— The anterior adductor muscle scar, particularly at the posterior margin, is more deeply incised than the posterior adductor muscle scar. This feature is seen in many veneroids and also in *Glossus*. *Pliocardia* has a small pallial sinus, a typical veneroid feature.

CONCLUSIONS

After a careful comparison of the morphology of *Pliocardia* with veneroids and glossoids, it appears that *Pliocardia* is related to the veneroids. Within the superfamily Veneracea, *Pliocardia* has morphologic characters most like those of the chionids and meretrecids. The shape of the shell, ornamentation, hinge teeth, and flexure near the posterior end are characters like those of the chionids. On the other hand, these same morphologic characters are like those of the meretrecids. The *Transennella*-like grooves found in *Pliocardia* are never present in the chionids. Although the number of hinge teeth in *Pliocardia* is more nearly like that of the chionids, their shape and position is more like that of the meretrecids (figs. 4, 7). In summary, it is my opinion that *Pliocardia* is related to a meretrecid and probably most closely related to *Transennella* because of the peculiar grooves on the interior ventral border. The hinge teeth show a striking resemblance to those of some species of *Pitar*. The systematic position of *Pliocardia* can be tentatively shown as follows:

Family Meretrecidae Frizzell, 1936
  Subfamily Meretrecinae Fischer, 1887
  Subfamily Pitarinae Stewart, 1930
  Subfamily Pliocardiinae Woodring, 1925
    Genus *Pliocardia* Woodring, 1925
      Pliocardia bowdeniana (Dall), 1903

On the basis of similarity of shell morphology, the Pliocardiinae appear to be more closely related to the Pitarinae than to the Meretrecinae.

The small pallial sinus, the thick shell, the *Transennella*-like grooves, and the hinge of the left valve leave no doubt that *Pliocardia* is an aberrant veneroid. It must be recognized that even the highly developed hinge of the veneroids shows variation, and that occasionally in the past some aberrant and short-lived groups have shown unusual deviations from the typical veneroid hinge.

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ACKNOWLEDGMENTS

I am greatly indebted to Dr. Harold E. Vokes and Mr. Druid Wilson of the Department of Geology at The Johns Hopkins University for some valuable suggestions and the loan of additional specimens. Mrs. Sally Lee made the drawings for the paper.

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JOURNAL OF PALEONTOLOGY, VOL. 27, NO. 5, PP. 706–707, SEPTEMBER 1953

PERIOD OF EXISTENCE OF SOME LATE CENOZOIC PELECYPODS[1]

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ABSTRACT—The average period of existence of 20 species of late Cenozoic pelecypods from the Atlantic Coastal Plain was about 6.5 million years. The shortest-lived species existed less than 1 million years, the longest-lived species more than 15 million years. In general, the longer a species existed, the greater was the number of individuals, the amount of variation, and the geographic range.

AT PRESENT there are few published data on the periods of existence of molluscan species. I studied the life spans of 20 species of pelecypods from the East Coast of the United States, New Jersey to Florida, ranging from Miocene to Recent. The late Cenozoic beds of this area are very fossiliferous and have been well collected since the early part of the nineteenth century. Large, well documented collections are in the U. S. National Museum.

The pelecypod species of this study were selected for their distinctiveness so that species problems could be minimized. Glycymerids and chamids comprise nearly half of the species examined because I am most familiar with them and also because these two moderate-sized families seem to be typical of pelecypod rates of evolution and are represented by some long-lived and some short-lived species.

In this work the Miocene is considered to have lasted approximately 16 million years, the Pliocene 10 million years, and the Pleistocene 1 million years. The relative age and correlation of formations was taken from the approximations of Cooke, Gardner, and Woodring, 1943. It is admitted that the actual time of origin and time of extinction of each species are not known. Despite these admitted limitations, the accumulated data presented herein are considered accurate enough to give some idea of rate of evolution in pelecypods.

Two of the chamid species studied are homonyms and are renamed. *Chama crassa* Heilprin, 1887, pp. 93, 94, is a homonym of *Chama crassa* W. Smith, 1817, p. 80. *Chama crassa* Heilprin is here renamed *Chama heilprini*. *Chama striata* Emmons, 1858, p. 288, is a homonym of *Chama striata* W. Smith, 1817, p. 45. *Chama striata* Emmons is here renamed *Chama emmonsi*.

The shortest-lived species studied is *Euloxa latisulcata* (Conrad) from the middle Miocene of Virginia. This aberrant veneroid genus is monotypic and is known from only a dozen or so specimens collected from three localities. Its period of existence was probably less than 1 million years. *Euloxa latisulcata* was selected to show that some pelecypod species are short-lived and rare. *Glycymeris aberrans* is another short-lived species which is known from only a few specimens from South Carolina and Florida. Unlike *Euloxa latisulcata*, *Glycymeris aberrans* belongs to a large genus which contains some long-lived species. The period of existence of *Glycymeris aberrans* in the late Miocene was about 1 million years. The remaining 18 species have a life span of from 2 million to more than 15 million years. The two longest-lived species, *Glycymeris subovata* and *Glycymeris americana*, are represented by a large number of individuals over a wide geographic area and show a great amount of variation. One interesting variant of *Glycymeris americana*, the mutant rugose, had a period of existence of about 3 million years during the late Miocene (Nicol, 1953). *Glycymeris americana* is still living, but it appears to be nearing extinction.

The average life span of the 20 species studied was approximately 6.5 million years.

Species having longer periods of existence generally are represented by a greater number of individuals, show a greater amount of

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SPECIES	GEOGRAPHIC RANGE	LIFE SPAN IN YEARS	GEOLOGIC RANGE
Euloxa latisulcata	Virginia	<1 million	Middle Miocene
Glycymeris aberrans	South Carolina-Florida	1 million	Upper Miocene
Pecten humphreysii	New Jersey, Maryland	2 million	Middle Miocene
Callista marylandica	New Jersey, Maryland	3 million	Middle Miocene
Glycymeris parilis	New Jersey, Maryland	3 million	Middle Miocene
Pecten madisonius	New Jersey-Virginia	3 million	Middle Miocene
Anomalocardia penita	Florida	3 million	Lower Miocene
Carolia floridana	South Carolina-Florida	3 million	Lower Miocene
Pseudochama corticosa	Virginia-South Carolina	4 million	Upper Miocene
Chama heilprini	Florida	6 million	Pliocene
Spondylus rotundatus	Florida	6 million	Pliocene
Pseudochama draconis	Florida	8 million	Lower, middle Miocene
Noetia (*Eontia*) *incile*	Virginia-Florida	8 million	Middle, upper Miocene
Pedalion maxillata	New Jersey-Virginia	8 million	Middle, upper Miocene
Pecten jeffersonius	Maryland-Florida	8 million	Middle, upper Miocene
Striarca centenaria	New Jersey-South Carolina	10 million	Middle, upper Miocene
Anadara rustica	South Carolina-Florida	12 million	Upper Miocene, Pliocene
Chama emmonsi	Virginia-Florida	12 million	Upper Miocene, Pliocene
Glycymeris subovata	Maryland-Florida	13 million	Miocene
Glycymeris americana	Virginia-Florida	>15 million	Upper Miocene-Recent
(mutant rugose)	Virginia-Florida	3 million	Upper Miocene
Average period of existence for the 20 species		6.5 million	

variation, and have a wider geographic distribution than species having shorter periods of existence.

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MANUSCRIPT RECEIVED AUGUST 22, 1952

JOURNAL OF PALEONTOLOGY, VOL. 27, NO. 5, PP. 708–733, PLS. 74–77, 1 FIG., SEPTEMBER 1953

MIOCENE FORAMINIFERA FROM THE TUBARA BEDS OF NORTHERN COLOMBIA

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ABSTRACT—The Tubara beds of the department of Atlantico, northern Colombia, contain a foraminiferal fauna of 83 species and varieties of which 15 are new and are described here. Two microfaunal zones are recognized: the lower, Zone I, is placed in the upper part of the middle Miocene and correlated with the Gurabo formation and its equivalents in the Dominican Republic; the upper, Zone II, is placed in the upper Miocene and provisionally related to the Bowden and Buff Bay assemblages and also to the fauna of the upper part of the Choctawhatchee formation. Evidence of connection between the Caribbean and the Pacific in lower Miocene and upper middle Miocene time is discussed.

INTRODUCTION

INFORMATION published to date on the middle and upper Miocene beds of northern Colombia has been confined largely to a consideration of megafossils; the only mention of the associated Foraminifera was that made by Renz (1949). The present report constitutes the first step in a program designed to remedy this situation.

Grateful acknowledgment is made to the management of the Tropical Oil Company for permission to publish this paper and to the members of the paleontological section, especially Dr. Viktor Petters, for advice and criticism received during the course of the work. Much of the drudgery of picking and preparation of the manuscript was taken over by my wife without whose assistance completion of the present paper would have been impossible. The excellent camera lucida illustrations were drawn by Sr. Alfonso Peña. Lastly, special thanks are due Dr. Brooks Ellis of the American Museum of Natural History, for critical review of the manuscript and material of this report, for without his aid it would have been hopeless to attempt such a paper in view of the writer's geographic remoteness from sources of literature and depositories of type material.

TUBARA BEDS

The only description in the literature of the section which includes the foraminiferal beds of this report is that of F. M. Anderson. His first brief mention (1926, p. 387, p. 399) did little more than put on record the name Tubara Group (misspelled "Tubera" by Anderson). A later paper (1927) listed megafossils from the lower part of the section and set up a lettered horizon designation from M to T. His final treatment (1929) consisted of a somewhat detailed listing of the megafossils corresponding to the horizon designations of his 1927 paper.

It would appear that the section containing the faunas listed here comprises horizons O to S of Anderson's Tubara Group. For the purposes of this report, these beds will be referred to as the "Tubara beds," bearing in mind that this is a geographic rather than a formational designation.

The samples which furnished the material studied were collected by Mr. J. M. Browning and Mr. E. M. Anderson, Tropical Oil Company geologists, from the immediate neighborhood of the village of Tubara, a small community which lies approximately 25 kilometers southwest of Barranquilla, in northern Colombia. The relative position of Tubara and Barranquilla and the placement of samples specifically mentioned in the text are indicated on the accompanying map, figure 1.

LITHOLOGY

The following lithologic description is modified from a Tropical Oil Company report by Browning and Anderson; their description may be paraphrased as follows: The section consists of 627 meters of beds of which the basal portion is characterized

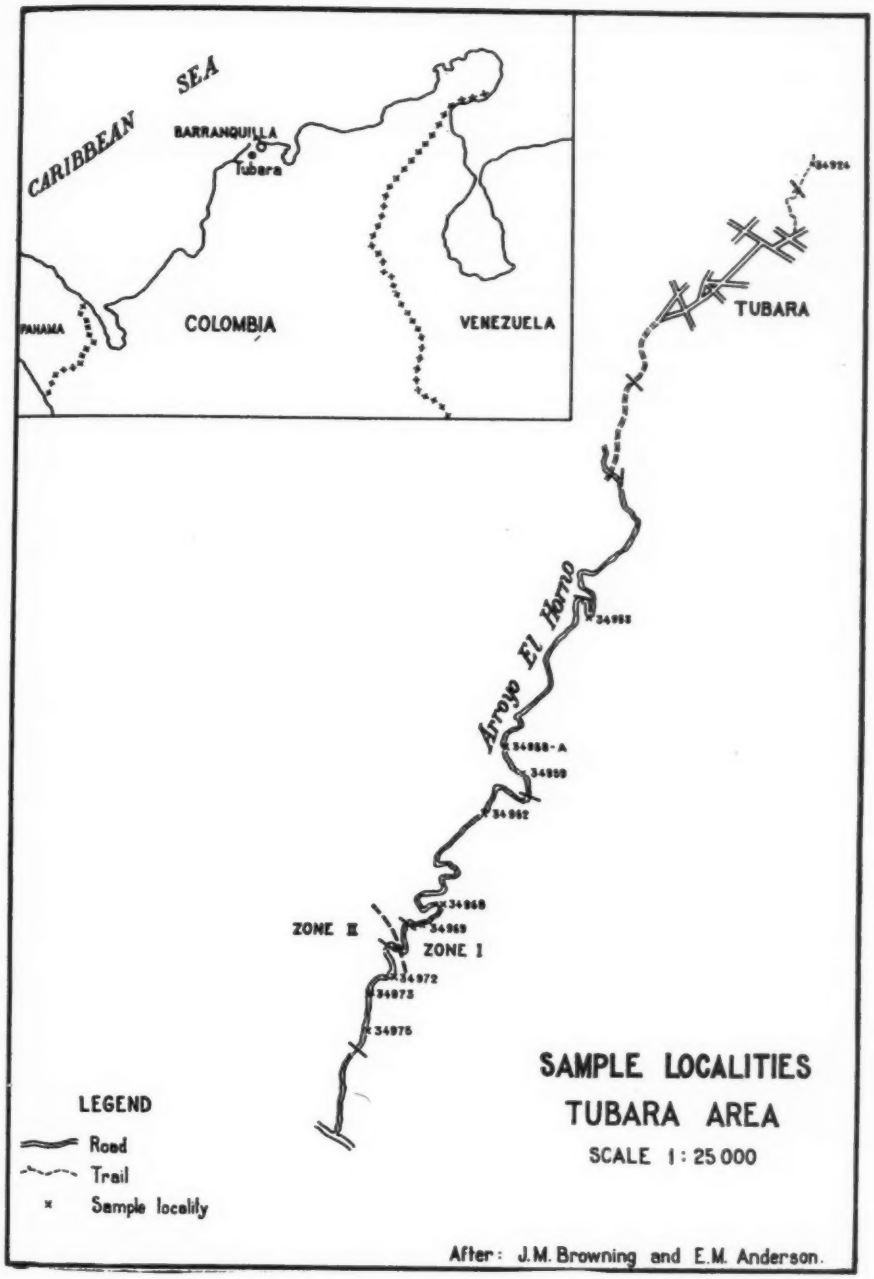


FIG. 1—Map of northern Colombia and detail in vicinity of Tubara.

by fine to coarse-grained and locally pebbly sandstones with light to medium gray waxey shale interbeds, the latter locally becoming silty. Two hundred meters up from the base is an eighteen-meter bed of hard, light-brown calcareous shale which caps the hill on which the village of Tubara is located.

The next 100 meters of overlying section is composed of interbedded shales and sandstones. The shales are light gray and are locally tuffaceous. The sandstones are fine-grained and friable.

The upper half of the section is predominantly fine-grained sandstone and siltstone with a few minor shales and occasional calcareous sandstone layers. Generally, the bedding is well defined with only occasional massive beds of sandstone.

FAUNA

The 83 species and varieties listed in table 1 are organized in the form of a check list that indicates distribution within the Tubara beds, occurrence of the same species in the Buff Bay or Bowden beds of Jamaica, the Choctawhatchee formation of Florida, the middle or upper Miocene of the Dominican Republic and the Recent of either the Atlantic or the Pacific. A generalized record of previously reported fossil occurrences of the Tubara species is carried in the last column. Here, it has been indicated whether the previous record was from the Atlantic or the Pacific seaboard.

The above records for the Buff Bay, Bowden, Choctawhatchee and Dominican Republic faunas were based upon the work of Cushman and Todd (1945), Palmer (1945), Cushman and Ponton (1932) and Bermudez (1949), respectively. The lists for the Recent and generalized Tertiary occurrences are based upon the reference sources which appear under the discussion of individual species in the systematic section.

ZONATION

The Tubara beds are divisible into two zones on the basis of microfaunal content. The lower of these has been designated Zone I. It occupies approximately 490 meters of section and rests unconformably upon beds of lower Miocene age. Zone II conformably overlies Zone I and occupies at least 137 meters of section. The upper limit of Zone II has not been defined.

Of the 59 species which occur in Zone I, *Bifarina hancocki* is the most characteristic. It is found in some abundance in almost every sample and appears to be limited to this zone. There are 13 other species which are recorded as occurring in Zone I but not in Zone II. However, it is expected that further collecting would reduce this number as several of the occurrences are represented by single or very rare specimens and probably give a false idea of the range. The reader is referred to table 1 for a detailed accounting of the 83 species which make up the complete fauna of this and the following zone.

Zone II is characterized by two species of *Cymbaloporetta*, *Bifarina pacifica* and *Compressigerina coartata*. The last two species are rather rare, but one or the other is found in almost every sample. Of the 69 species which occur here, 24 are not recorded from Zone I.

CORRELATION

Unfortunately there is no published microfauna that corresponds closely to that of Zone I. Of the 59 species recorded from Zone I, only 18 are represented in either the Bowden or Buff Bay faunas, only 14 are identical with Choctawhatchee forms and not more than 12 are listed from the Gurabo formation of the Dominican Republic. Furthermore, the relationship to the Haitian Port-au-Prince fauna of Coryell and Rivero (1940) is even more obscure as there is a record of only ten species in common.

There is, however, a rather large molluscan fauna carried in the beds of Zone I and Mr. F. V. Stevenson of the Tropical Oil Company is authority for the statement that the majority of the species represented are those which are also listed from the Gurabo of the Dominican Republic, the Brasso beds of Trinidad and the upper part of the Gatun of Costa Rica (personal communication).

The presence of a number of distinctive species in common in Zone II and both the Buff Bay and the Bowden beds was first thought to indicate a close degree of relationship between these three assemblages. However, in view of the extended ranges re-

ported by Bermudez (1949) for many of these species and in view of the ever-present facies problem, it would be well to discount any superficial resemblance until more is known of the absolute ranges of all of the forms present. The most that can be safely done at the moment is to record that of the 69 species occurring in Zone II, 25 appear in the Buff Bay list and 28 in the Bowden list.

As a warning against a too blind use of statistics, it may be noted that Zone II has 20 species in common with the Gurabo as against a total of only 14 in common with the Mao, an indicated relationship directly opposed to that suggested by the megafossils.

There appears to be no basis for hypothecating a closer relationship of Zone II to either Buff Bay or to Bowden. This raises the question as to whether or not there is any time difference between the Buff Bay and Bowden occurrences.

Cushman and Jarvis (1930) were of the opinion that the two localities were equivalent. Trechmann, however (1930, pp. 204–205), grouped the Buff Bay exposures with the Manchioneal thus placing them stratigraphically higher than the Bowden.

If the first view expressed above is correct, the differences between the faunas must be caused by a minor difference in facies. Should Trechmann's view represent the truth, the difference between the two levels must be slight as witness the intermingling of the two faunas in the beds of Zone II. Indeed, were it not for the troublesome problem of fixing the middle-upper Miocene time boundary the whole question could be passed over as of little moment.

Of some bearing on the above problem is the fact that of the 19 Zone II species which appear also on the Choctawhatchee list nearly all either range into or are confined to the upper part of the latter formation.

AGE

The resemblance of the Zone I megafauna to assemblages reported from the Gurabo of the Dominican Republic, the Brasso beds of Trinidad and the Gatun formation of Costa Rica would indicate a middle Miocene age for this part of the Tubara section. Such a conclusion would be in agreement with the views of F. M. Anderson (1929, p. 103).

In contradistinction, the age of Zone II is not easily established. If it be considered equivalent to the Bowden there would be justification for placing it in the upper part of the middle Miocene in accordance with Woodring (1928, pp. 56–57, p. 108). At the same time, there is as much justification for correlation of Zone II with the Buff Bay fauna and if, in truth, the latter is to be grouped with the Manchioneal, an upper Miocene age assignment for Zone II would not be unreasonable. The last statement is based upon the position indicated for the Manchioneal by Woodring in a chart prepared by Cooke, Gardner and Woodring (1943, chart no. 12).

One other point that might indicate an upper Miocene age for Zone II is the occurrence of a number of its species in the upper part of the Choctawhatchee formation.

Inasmuch as Zone I would appear to fall within the upper part of the middle Miocene, and Zone II is separated from Zone I by a clear faunal break, in the light of the above discussion, the writer feels impelled to place the middle-upper Miocene break between the two zones. Certainly this would seem to be by far the most practical course in Colombia.

ECOLOGY

Both zones contain a preponderance of genera and species indicative of accumulation in the open sea in water of moderate depth, that is, within the neritic zone. The fauna as a whole is tropical and most of the species with representatives in the Recent have been reported in the Caribbean or the tropical Pacific. The presence in Zone II of both *Cymbaloporetta* and a *Tretomphalus* with a *Cymbaloporetta* stage may be taken as a particularly good indication of warm-water conditions in this part of the section (Myers, 1940, p. 26).

One phenomenon for which no explanation is attempted is that almost all of the previously described Tubara forms are of smaller size than the types.

FAUNAL RELATIONSHIPS

No less than 26 of the Tubara species are recorded in the Recent from either the

Pacific or both the Atlantic and the Pacific. This seems a very high percentage of Pacific elements but when it is considered that there was free communication between the Pacific and Caribbean at least through the Oligocene and into the lower Miocene it would not be surprising to find that some descendants of the earlier faunas have survived on both sides of the present divide.

Inspection of the fossil record gives a similar result. The admittedly incomplete compilation in table 1 lists 14 species that have been recorded from both the Atlantic and Pacific seaboards and one, *Bolivina brevior*, that has been previously known only from the Miocene of the Pacific Coast of North America.

However, when an attempt is made to eliminate all species both fossil and Recent that might represent a lower Miocene or older stock there remains an indissoluble residue that can be explained only by the existence of a more recent connection between the oceans. These species together with their distribution within the zones may be listed as follows:

Limited to Zone I

Bolivina brevior

Limited to Zone II

Cymbaloporetta bradyi
Cymbaloporetta squammosa
Tretomphalus pacificus

Both zones

Bolivina ligularia
Dyocibicides biserialis
Loxostomum limbatum var. *costulatum*
Planorbulina mediterranensis
Reussella pulchra

Further investigation may extend the ranges downward, but it is noteworthy that, to date, all Pacific elements encountered in Zone I are concentrated toward the top. This is taken to mean that communication with the Pacific, which was closed sometime during the lower Miocene, was reopened toward the close of Zone I time or, in other words, late in the middle Miocene.

SYSTEMATICS

The arrangement followed is that of Cushman. This is not meant to express an opinion or preference as to system of classification, but rather to conform to an order of arrangement currently in wide use.

Types are deposited in the Department

EXPLANATION OF PLATE 74

FIG. *1*—*Textularia flintii* Cushman var. *curta* Cushman. ×21. *a*, Side view; *b*, apertural view. (p. 713)

2—*Textularia mexicana* Cushman. ×32. *a*, Side view; *b*, apertural view. (p. 713)

3—*Quinqueloculina lamarckiana* d'Orbigny. ×33. *a*, Side view; *b*, apertural view; *c*, opposite side. (p. 715)

4—*Quinqueloculina polygona* d'Orbigny. ×63. *a*, Side view; *b*, apertural view; *c*, opposite side. (p. 716)

5—*Quinqueloculina pulchella* d'Orbigny. ×66. *a*, Side view; *b*, apertural view; *c*, opposite side. (p. 716)

6—*Quinqueloculina subpoeyana* Cushman. ×61. *a*, Side view; *b*, apertural view; *c*, opposite side. (p. 716)

7—*Massilina crenata* (Karrer). ×64. *a*, Side view; *b*, edge view; *c*, opposite side. (p. 716)

8—*Vertebralina colombiana* Redmond, n. sp. Holotype, ×63. *a*, Side view; *b*, apertural view; *c*, opposite side. (p. 716)

9—*Marginulina subaculeata* (Cushman) var. *glabrata* (Cushman). ×65. *a*, Side view; *b*, edge view. (p. 716)

10—*Lagena alternans* Terquem. ×63. *a*, Side view; *b*, apertural view. (p. 717)

11—*Lagena colombiana* Redmond, n. sp. Holotype, ×58. *a*, Side view; *b*, apertural view. (p. 717)

12—*Lagena hexagona* (Williamson) var. *scalariformis* (Williamson). ×65. *a*, Side view; *b*, apertural view. (p. 717)

13—*Lagena laevis* (Montagu). ×68. *a*, Side view; *b*, apertural view. (p. 717)

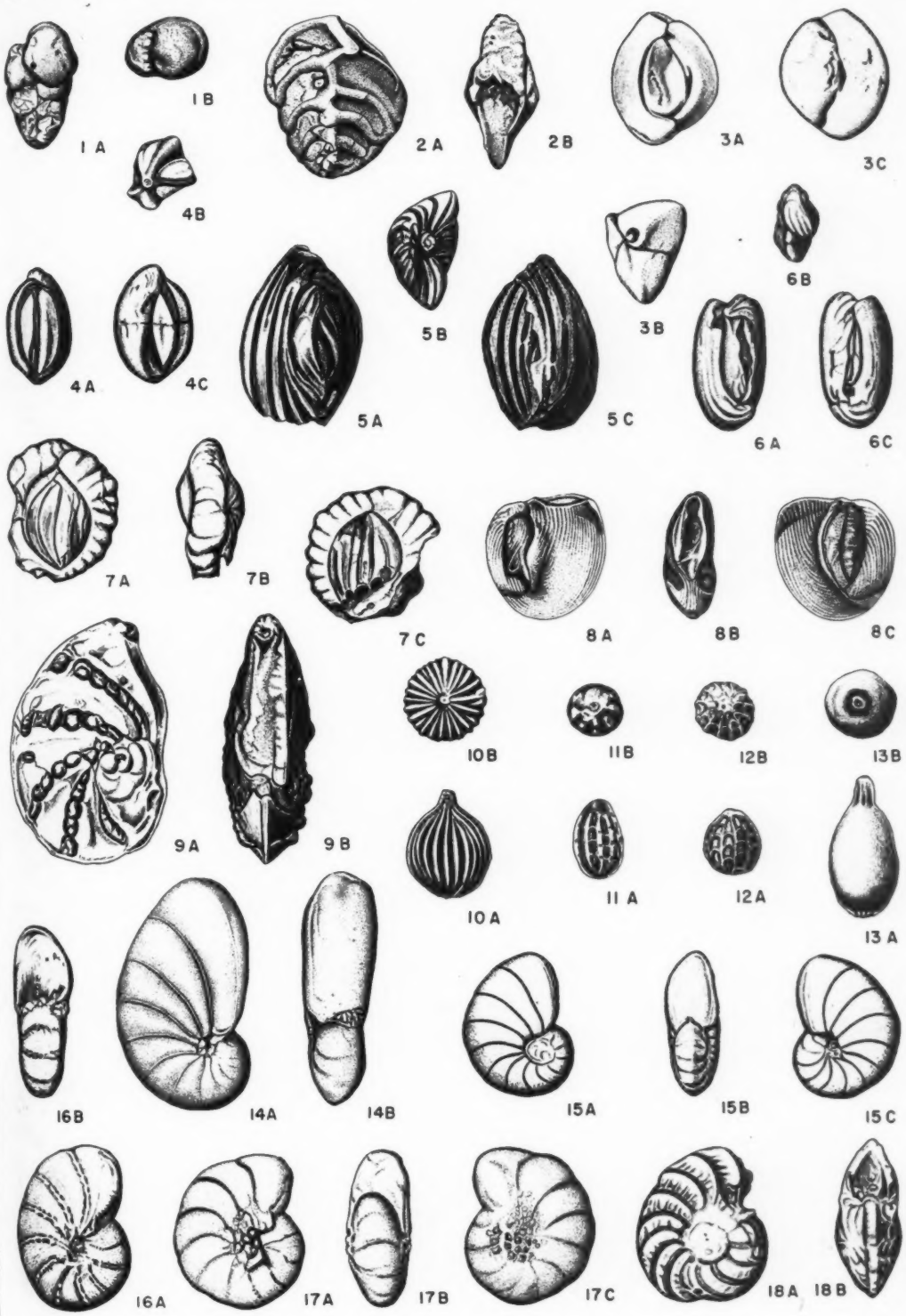
14—*Nonion grateloupii* (d'Orbigny). ×68. *a*, Side view; *b*, edge view. (p. 717)

15—*Nonionella atlantica* Cushman. ×32. *a*, Side view; *b*, edge view; *c*, opposite side. (p. 717)

16—*Elphidium articulatum* (d'Orbigny). ×62. *a*, Side view; *b*, edge view. (p. 718)

17—*Elphidium australe* Cushman & Parker. ×62. *a*, Side view; *b*, edge view; *c*, opposite side. (p. 718)

18—*Elphidium granti* Kleinpell var. *tubaraense* Redmond, n. var. Holotype, ×66. *a*, Side view; *b*, edge view. (p. 718)



Redmond, Miocene Tubara Foraminifera, Colombia

Redmond, Miocene Tubara Foraminifera, Colombia

of Micropaleontology, American Museum of Natural History (AMNH), New York City.

Family TEXTULARIIDAE
Genus TEXTULARIA Defrance, 1824
TEXTULARIA FLINTII Cushman var. CURTA Cushman
Plate 74, figures 1a, b

Textularia flintii curta CUSHMAN, 1922, U. S. Nat. Mus. Bull. 104, pt. 3, p. 14, pl. 2, figs. 2, 3; CUSHMAN & TODD, 1945, Cushman Lab. Foram. Research Special Pub. 15, p. 2, pl. 1, fig. 5; BERMUDEZ, 1949, idem, Special Pub. 25, p. 61, pl. 2, figs. 13, 14.

This species is common in both zones of the Tubara but is usually represented only by the initial ends. Occasional specimens, however, attain a large size and in so doing pass through the stage represented by the figures in the above references and develop final chambers that approach those of *T. candeiana* d'Orbigny in shape.

Dimensions of figured specimen.—Length, 0.90 mm.; width, 0.58 mm.; thickness, 0.42 mm.

Plesiotype.—AMNH.

TEXTULARIA MEXICANA Cushman
Plate 74, figures 2a, b

Textularia mexicana CUSHMAN, 1922, U. S. Nat. Mus., Bull. 104, pt. 3, p. 17, pl. 2, fig. 9;

EXPLANATION OF PLATE 75

FIG. *1*—*Plectofrondicularia floridana* Cushman. ×64. *a*, Side view; *b*, apertural view. (p. 719)
2—*Buliminella elegantissima* (d'Orbigny). ×65. (p. 719)
3—*Buliminella subfusiformis* Cushman. ×62. *a*, Side view; *b*, apertural view. (p. 719)
4—*Bulimina mexicana* Cushman. ×64. (p. 719)
5—*Entosolenia atlantica* Redmond, n. sp. Holotype, ×56. *a*, Side view; *b*, apertural view. (p. 719)
6—*Entosolenia* aff. *Entosolenia orbignyana* (Seguenza) var. *flintii* (Cushman). ×68. *a*, Side view; *b*, apertural view. (p. 720)
7—*Virgulina pontoni* Cushman. ×68. *a*, Side view; *b*, opposite side. (p. 720)
8—*Bolivina brevior* Cushman. ×63. *a*, Side view; *b*, apertural view. (p. 720)
9—*Bolivina imporcata* Cushman & Renz. ×67. *a*, Side view; *b*, apertural view. (p. 720)
10—*Bolivina interjuncta* Cushman var. *bicostata* Cushman. ×35. *a*, Side view; *b*, apertural view. (p. 720)
11—*Bolivina ligularia* Schwager. ×71. *a*, Side view; *b*, apertural view. (p. 720)
12—*Bolivina marginata* Cushman var. *multicostata* Cushman. ×67. *a*, Side view; *b*, apertural view. (p. 721)
13—*Bolivina plicatella* Cushman. ×67. *a*, Side view; *b*, apertural view. (p. 721)
14—*Bolivina tortuosa* (Brady). ×60. *a*, Side view; *b*, apertural view. (p. 721)
15—*Bolivina tortuosa* (Brady) var. *lissa* Redmond, n. var. Holotype, ×66. *a*, Side view; *b*, apertural view. (p. 721)
16—*Loxostomum limbatum* (Brady) var. *costulatum* (Cushman). ×65. *a*, Side view; *b*, apertural view. (p. 721)
17—*Bifarina hancocki* Cushman & McCulloch. Microspheric specimen. ×67. *a*, Side view; *b*, apertural view. (p. 722)
18—*Bifarina hancocki* Cushman & McCulloch. Megalospheric specimen. ×58. *a*, Side view; *b*, apertural view. (p. 722)
19—*Bifarina pacifica* Cushman & McCulloch. Megalospheric (?) specimen. ×66. *a*, Side view; *b*, apertural view. (p. 722)
20—*Bifarina pacifica* Cushman & McCulloch. Microspheric (?) specimen. ×63. *a*, Side view; *b*, apertural view. (p. 722)
21—*Rectobolivina paucicostata* (Cushman & Todd). ×67. *a*, Side view; *b*, apertural view. (p. 722)
22—*Reussella bordata* Redmond, n. sp. Holotype, ×64. *a*, Side view; *b*, apertural view. (p. 722)
23—*Reussella miocenica* Cushman. ×64. *a*, Side view; *b*, apertural view. (p. 722)
24—*Reussella pulchra* Cushman. ×69. *a*, Side view; *b*, apertural view. (p. 723)
25—*Pavonina* cf. *Pavonina miocenica* Cushman & Ponton. ×31. (p. 723)
26—*Uvigerina isidroensis* Cushman & Renz. ×66. *a*, Side view; *b*, apertural view. (p. 723)
27—*Uvigerina peregrina* Cushman. ×64. *a*, Side view; *b*, apertural view. (p. 723)
28—*Angulogerina colombiana* Redmond, n. sp. Holotype, ×63. *a*, Side view; *b*, apertural view. (p. 723)
29—*Angulogerina jamaicensis* Cushman & Todd. ×62. *a*, Side view; *b*, apertural view. (p. 723)
30—*Compressigerina coartata* (Palmer). ×62. *a*, Side view; *b*, apertural view. (p. 723)
31—*Spirillina limbata* Brady var. *denticulata* Brady. ×63. (p. 724)
32—*Discorbis floridensis* Cushman. ×60. *a*, Dorsal view; *b*, edge view; *c*, ventral view. (p. 724)

TABLE 1—OCCURRENCE OF THE TUBARA FORAMINIFERA.

SYMBOLS
vr very rare — A Atlantic
r rare — P Pacific
rc rare to common
c common
a abundant
x not specified
* Equivalent horizon

	Tubara Zone I	Tubara Zone II	Buff Bay	Bowden	Choctawhatchee	Gurabo	Mao	Recent	Fossil
Amphistegina angulata		vr	x	a		a			A
Amphistegina lessonii	a	r	x		x	x	c	AP	A
Amphistegina lessonii bowdenensis	r?	c	x	a					A
Angulogerina colombiana, n. sp.	a	a					•		
Angulogerina jamaicensis	a	rc	x						A
Asterigerina carinata		vr		vr		r		A	A
Asterigerina pettersi, n. sp.	c	c							
Bifarina hancocki	a							P	
Bifarina pacifica		rc						P	
Bolivina brevior	vr								P
Bolivina imporcata	r	r							A
Bolivina interjuncta bicostata	a	a				r		P	AP
Bolivina ligularia	vr	vr	vr					P	A
Bolivina marginata multicostata	r	r	x	r	x				A
Bolivina plicatella	r		x		x			A	A
Bolivina tortuosa	r	r	c	x				AP	A
Bolivina tortuosa lissa, n. var.	r							P	A
Bulimina mexicana		vr	x				c	AP	A
Buliminella elegantissima	a	r			x		c	AP	AP
Buliminella subfusiformis	r	r			r				AP
Cancris sagra	vr	vr		x		c	x	A	A
Cassidulina caribeana, n. sp.	a	r	x	x	x	r	r		A
Cassidulina vestae, n. sp.	vr	vr							
Cibicides concentricus	a	a		vr	x			A	A
Cibicides io	a	a				c		A	A
Compressigerina coartata		r	x	x		a			A
Cymbaloporetta bradyi		c						AP	
Cymbaloporetta squammosa		c				r		AP	A
Discorbis floridanus		r		x	c		a*	A	A
Discorbis floridensis		rc	x	r		a		A	A
Discorbis terquemi	c			x	x	c		A	A
Dyocibicides biserialis	c	c	r	x	x	x	x	AP	A
Elphidium articulatum		a						A	A
Elphidium australe	a							A	
Elphidium granti tubaraense, n. var.	r	r							
Entosolenia atlantica, n. sp.	rc								
Entosolenia aff. *E. orbignyana flintii*		vr							
"Eponides" lateralis	vr	vr	x	vr	x			A	A
"Eponides" parantillarum	r	r	c	x		a			A
"Eponides repandus"	c	c				r		AP	A
Gavelinopsis woodringi, n. sp.	c	c							
Glabratella browningi, n. sp.	vr	r							
Globigerina altispira		vr	c			c			A
Globigerinoides ruber	c	c	x	x				A	AP
Globigerinoides tricameratus	r	r						P	AP
Globorotalia menardii	r	r		x	x	a		A	AP
Lagena alternans		vr						A	
Lagena colombiana, n. sp.	r								
Lagena hexagona		vr	x		x	r	r	AP	AP
Lagena hexagona scalariformis	r	r		x	x			AP	AP
Lagena laevis	r							AP	
Loxostomum limbatum costulatum	r	r		r				AP	A
Marginulina subaculeata glabrata	r		x					A	A
Massilina crenata		vr		vr				A	A

TABLE 1—*Continued*

SYMBOLS vr very rare r rare rc rare to common c common a abundant x not specified * Equivalent horizon A Atlantic P Pacific	Tubara Zone I	Tubara Zone II	Buff Bay	Bowden	Choctawhatchee	Gurabo	Mao	Recent	Fossil
Nonion grateloupi		r		x	x	a		A	A
Nonionella atlantica	a	r						A	
Orbulina universa		r	x	x	x			AP	AP
Pavonina miocenica		cf. vr		vr	x	r			A
Planorbulina mediterranensis	c	c		x				AP	A
Planulina ariminensis	c	c						A	A
Planulina wüllerstorfi	vr	vr					x*	AP	AP
Plectofrondicularia floridana	vr	vr		vr	x				A
Quinqueloculina lamarckiana	c	c	cf. vr	x	x		c	A	A
Quinqueloculina polygona		r		cf.x				A	A
Quinqueloculina pulchella	vr							AP	A
Quinqueloculina subpoeyana		vr			x			A	A
Rectobolivina paucicostata		vr	x						A
Reussella bordata, n. sp.	a	a							
Reussella miocenica		r	r	vr	x				A
Reussella pulchra	c	c	x					P	AP
Rotalia andersoni, n. sp.	c								
Rotalia beccarii	a	a						AP	AP
Rotalia sarmientoi, n. sp.	r	vr							
Siphonina pulchra	vr	vr	c	c		c	r*	A	A
Spirillina limbata denticulata		vr						A	
Textularia flintii curta	c	c	c				r	A	A
Textularia mexicana	r	vr	c			a	a	A	AP
Tretomphalus pacificus		r						P	
Uvigerina isidroensis	r	r							A
Uvigerina peregrina	r	r						AP	AP
Valvulineria olssoni, n. sp.	r	r							
Vertebralina colombiana, n. sp.	vr								
Virgulina pontoni	r								AP

CUSHMAN & BARBAT, 1932, Cushman Lab. Foram. Research Contr., vol. 8, p. 33, pl. 5, fig. 3; HEDBERG, 1937, Jour. Paleontology, vol. 11, p. 666, pl. 90, fig. 4; FRANKLIN, 1944, idem, vol. 18, p. 306, pl. 44, fig. 20; RENZ (as *T.* cf. *mexicana*), 1948, Geol. Soc. America Mem. 32, p. 170, pl. 12, fig. 2; BERMUDEZ, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 63, pl. 2, figs. 57–59.

Reference to the above figures will show that most of the forms figured as *T. mexicana* are less coarsely arenaceous than would appear to be the case with the type specimen. The same is true of the Tubara form, which occurs sparingly in Zone I and is represented by a single specimen in Zone II.

Dimensions of figured specimen.—Length, 0.75 mm.; width, 0.63 mm.; thickness, 0.33 mm.

Plesiotype.—AMNH.

Family MILIOLIDAE

Genus QUINQUELOCULINA d'Orbigny, 1826

QUINQUELOCULINA LAMARCKIANA d'Orbigny

Plate 74, figures 3a–c

Quinqueloculina lamarckiana D'ORBIGNY, 1839, in Ramon de la Sagra, Histoire physique, politique et naturelle de l'Île de Cuba; Foraminifères, p. 189, pl. 11, figs. 14–15; PALMER, 1945, Bull. Amer. Paleontology, vol. 29, no. 115, p. 29; BERMUDEZ, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 101, pl. 6, fig. 5.

Both Tubara zones contain common and typically developed representatives of this species.

Dimensions of figured specimen.—Length, 0.60 mm.; width, 0.50 mm.; thickness, 0.33 mm.

Plesiotype.—AMNH.

QUINQUELOCULINA POLYGONA d'Orbigny
Plate 74, figures 4a–c

Quinqueloculina polygona D'ORBIGNY, 1839, in Ramon de la Sagra, Histoire physique, politique et naturelle de l'Île de Cuba; Foraminifères, p. 198, pl. 12, figs. 21–23; CUSHMAN, 1929, U. S. Nat. Mus., Bull. 104, pt. 6, p. 27, pl. 3, figs. 5a–c; BERMUDEZ, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 102, pl. 6, fig. 11.

Quinqueloculina cf. *Q. polygona* d'Orbigny. PALMER, 1945, Bull. Amer. Paleontology, vol. 29, no. 115, p. 30.

Rare specimens in Zone II appear to fall within this species, but the chambers are not as widely separated as in d'Orbigny's figure. In this respect they are closer to Cushman's Tortugas material.

Dimensions of figured specimen.—Length, 0.28 mm.; width, 0.18 mm.; thickness, 0.13 mm.

Plesiotype.—AMNH.

QUINQUELOCULINA PULCHELLA d'Orbigny
Plate 74, figures 5a–c

Quinqueloculina pulchella D'ORBIGNY, 1826, Ann. Sci. Nat., sér. 1, tome 7, p. 303; CUSHMAN, 1929, U. S. Nat. Mus., Bull. 104, pt. 6, p. 34, pl. 6, figs. 7, 8.

One incomplete specimen found in the upper part of Zone I seems to represent this species.

Dimensions of figured specimen.—Length (incomplete), 0.40 mm.; width, 0.28 mm.; thickness, 0.15 mm.

Plesiotype.—AMNH.

QUINQUELOCULINA SUBPOEYANA Cushman
Plate 74, figures 6a–c

Quinqueloculina subpoeyana CUSHMAN, 1922, Carnegie Inst. Washington, Pub. 311, p. 66; CUSHMAN & PONTON, 1932, Florida Geol. Surv., Bull. 9, p. 44, pl. 2, figs. 4a–c.

A single broken specimen representing this form was found in Zone II.

Dimensions of figured specimen.—Length (incomplete), 0.33 mm.; width, 0.17 mm.; thickness, 0.10 mm.

Plesiotype.—AMNH.

Genus MASSILINA Schlumberger, 1893
MASSILINA CRENATA (Karrer)
Plate 74, figures 7a–c

Spiroloculina crenata KARRER, 1868, K. Akad. Wiss. Wien, Mat.-Naturw. Cl., Sitzber., Bd. 58, Abt. 1, p. 135, pl. 1, fig. 9.

Massilina crenata (Karrer). CUSHMAN, 1917, U. S. Nat. Mus., Bull. 71, pt. 6, p. 57, pl. 20, fig. 2; 1929, idem, Bull. 104, pt. 6, p. 38, pl. 7, fig. 5.

This species is represented by one poorly preserved individual encountered in Zone II. The resemblance to Karrer's figured specimen from the Miocene of Rumania is not too close, but the Tubara specimen appears identical with the Recent form figured by Cushman as *Massilina crenata* (Karrer).

Dimensions of figured specimen.—Length, 0.33 mm.; thickness, 0.17 mm.

Plesiotype.—AMNH.

Family OPHTHALMIDIIDAE
Genus VERTEBRALINA d'Orbigny, 1826
VERTEBRALINA COLOMBIANA
Redmond, n. sp.
Plate 74, figures 8a–c

Test compressed, the last two chambers making up nearly all of the final whorl, periphery bluntly angled, surface with numerous parallel striae; aperture elongate, narrow, slightly flaring and with a slight lip. Height, 0.32 mm.; width, 0.28 mm.; thickness, 0.12 mm.

This species is confined to Zone I where it is extremely rare.

Type locality.—Tropical Oil Company No. 34969.

Holotype.—AMNH, Cat. no. FT-1100.

Family LAGENIDAE
Genus MARGINULINA d'Orbigny, 1826
MARGINULINA SUBACULEATA (Cushman)
var. GLABRATA (Cushman)
Plate 74, figures 9a, b

Cristellaria subaculeata glabrata CUSHMAN, 1923, U. S. Nat. Mus., Bull. 104, pt. 4, p. 124, pl. 32, fig. 4; pl. 33, figs. 2–3; pl. 34, fig. 3.

Marginulina subaculeata glabrata (Cushman). CUSHMAN & TODD, 1945, Cushman Lab. Foram. Research Special Pub. 15, p. 18, pl. 3, fig. 3.

The Tubara form resembles the individual figured from Buff Bay by Cushman and Todd. It is found only in Zone I where it is rare.

Dimensions of figured specimen.—Length, 0.56 mm.; width, 0.38 mm.; thickness, 0.19 mm.

Plesiotype.—AMNH.

Genus NODOSARIA Lamarck, 1822

The Tubara material contains rare seg-

ments and isolated chambers of nodosarine forms which probably represent all of the rectilinear uniserial genera. Inasmuch as these forms are poorly represented, long ranging and the synonymies bewilderingly complex, no attempt has been made to work them out here.

Genus LAGENA Walker & Boys, 1784

LAGENA ALTERNANS Terquem

Plate 74, figures 10a, b

Lagena alternans TERQUEM, 1875, Essai sur le classement des animaux qui vivent sur la plage et dans les environs de Dunkerque; Premier fascicule, p. 20, pl. 1, fig. 4.

The only specimen of this form was one found in Zone II.

Dimensions of figured specimen.—Length, 0.25 mm.; diameter, 0.20 mm.

Plesiotype.—AMNH.

LAGENA COLOMBIANA Redmond, n. sp.

Plate 74, figures 11a, b

Test small, round in cross section, oval in longitudinal section; surface ornamented with nine longitudinal costae from which branch exceedingly fine, hair-like lines that sometimes reach across to the adjoining costae and sometimes double back in loops which are superimposed upon the originating costae, principal costae sometimes twisted; aperture a small, circular hole on the blunt anterior end of the test. Diameter, 0.13 mm.; length, 0.20 mm.

This inconspicuous little form appears to be confined to Zone I where it is quite rare.

Type locality.—Tropical Oil Company No. 34969.

Holotype.—AMNH, Cat. no. FT-1101.

LAGENA HEXAGONA (Williamson)

Entosolenia squamosa (Montagu) var. *hexagona* WILLIAMSON, 1848, Ann. Mag. Nat. Hist., ser. 2, vol. 1, p. 20, pl. 2, fig. 23.

Lagena hexagona (Williamson). CUSHMAN, 1929, Cushman Lab. Foram. Research Contr., vol. 5, p. 72, pl. 11, fig. 18; CUSHMAN & TODD, 1945, Cushman Lab. Foram. Research Special Pub. 15, p. 33, pl. 5, fig. 14.

This species is found only in Zone II where it is extremely rare.

Dimensions of typical specimen.—Length. 0.17 mm.; diameter, 0.13 mm.

Plesiotype.—AMNH.

LAGENA HEXAGONA (Williamson) var. SCALARIFORMIS (Williamson)

Plate 74, figures 12a, b

Entosolenia squamosa (Montagu) var. *scalariformis* WILLIAMSON, 1848, Ann. Mag. Nat. Hist., ser. 2, vol. 1, p. 20, pl. 2, figs. 21–22.

Lagena hexagona (Williamson) var. *scalariformis* (Williamson). CUSHMAN, 1913, U. S. Nat. Mus., Bull. 71, pt. 3, p. 17, pl. 6, fig. 4; 1929, Cushman Lab. Foram. Research Contr., vol. 5, p. 72, pl. 11, fig. 17.

The variety is much more common than the typical form in the Tubara beds, being listed as rare in both zones.

Dimensions of figured specimen.—Length, 0.16 mm.; diameter, 0.13 mm.

Plesiotype.—AMNH.

LAGENA LAEVIS (Montagu)

Plate 74, figures 13a, b

Vermiculum laeve MONTAGU, 1803, Test. Brit., p. 524.

Lagena laevis (Montagu). CUSHMAN & GRAY, 1946, Cushman Lab. Foram. Research Special Pub. 19, p. 18, pl. 3, figs. 21–23.

A rare and quite variable form in Zone I may be assigned to this species. The figured specimen is an elongate variant.

Dimensions of figured specimen.—Length, 0.32 mm.; diameter, 0.15 mm.

Plesiotype.—AMNH.

Family NONIONIDAE

Genus NONION Montfort, 1808

NONION GRATELOUPII (d'Orbigny)

Plate 74, figures 14a, b

Nonionina grateloupii D'ORBIGNY, 1839, in Ramon de la Sagra, Histoire physique, politique et naturelle de l'Île de Cuba; Foraminifères, p. 46, pl. 6, figs. 6–7.

Nonion grateloupi (d'Orbigny). CUSHMAN, 1930, Florida Geol. Survey, Bull. 4, p. 36, pl. 6, figs. 1–3; BERMUDEZ, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 165, pl. 11, fig. 15.

This species is confined to Zone II where it is rare.

Dimensions of figured specimen.—Length, 0.50 mm.; width, 0.27 mm.; thickness, 0.16 mm.

Plesiotype.—AMNH.

Genus NONIONELLA Cushman, 1926

NONIONELLA ATLANTICA Cushman

Plate 74, figures 15a–c

Nonionella atlantica CUSHMAN, 1947, Cushman

Lab. Foram. Research Contr., vol. 23, p. 90, pl. 20, figs. 4, 5.

This form is abundant in Zone I and rare in Zone II.

Dimensions of figured specimen.—Length, 0.67 mm.; width, 0.48 mm.; thickness, 0.24 mm.

Plesiotype.—AMNH.

Genus ELPHIDIUM Montfort, 1808
ELPHIDIUM ARTICULATUM (d'Orbigny)
Plate 74, figures 16a, b

Polystomella articulata D'ORBIGNY, 1839, Voyage dans l'Amérique Méridionale; Foraminifères; tome 5, pt. 5, p. 30, pl. 3, figs. 9, 10.

Elphidium articulatum (d'Orbigny). CUSHMAN, 1930, U. S. Nat. Mus., Bull. 104, pt. 7, p. 26, pl. 10, figs. 6–8.

Elphidium poeyanum (d'Orbigny). CUSHMAN, 1930 (part), ibid., p. 25, pl. 10, figs 5a, b (not fig. 4); RENZ, 1948, Geol. Soc. America Mem. 32, p. 132, pl. 6, figs. 6a, b.

Numerous individuals of this species are present in Zone II of the Tubara. Variants range from the type with fewer and more inflated chambers figured by both Cushman and Renz as *E. poeyanum* (d'Orbigny) to specimens closely approximating d'Orbigny's original figure of *E. articulatum*. In connection with the latter, it is noteworthy that several of the Tubara individuals exhibit the triangular arrangement of pores on the apertural face so prominent in the original drawing. Where this arrangement of pores is well developed, the more normal line of openings along the base of the apertural face is apt to be suppressed, thus approaching the genus *Cribroelphidium* of Cushman and Bronnimann (1948, p. 18).

Dimensions of figured specimen.—Diameter, 0.41 mm.; thickness, 0.15 mm.

Plesiotype.—AMNH.

ELPHIDIUM AUSTRALE Cushman & Parker
Plate 74, figures 17a–c

Elphidium australis CUSHMAN & PARKER, 1931, U. S. Nat. Mus. Proc., vol. 80, art. 3, p. 12, pl. 2, figs. 8a, b.

Elphidium australe Cushman & Parker. CUSHMAN, 1939, U. S. Geol. Survey, Prof. Paper 191, p. 60, pl. 16, fig. 30.

This species was figured in 1931 by Cushman and Parker and refigured in 1939 by Cushman. The original drawing indicated that the aperture consisted not only of a line of circular pores at the base of the apertural face, but also a second line of pores higher up on the face. The 1939 figure eliminates the second line of pores thus making the drawing conform to the written description: "aperture consisting of numerous small circular pores at the base of the apertural face. . . ."

A form which is abundant in Zone I fits the description of this species very well both as to general form and proportion. It differs, however, in being appreciably smaller.

Dimensions of figured specimen.—Diameter, 0.37 mm.; thickness, 0.15 mm.

Plesiotype.—AMNH.

ELPHIDIUM GRANTI Kleinpell
var. TUBARAENSE Redmond, n. var.
Plate 74, figures 18a, b

Test planispiral, involute, umbonate; diameter less than twice the thickness in young specimens, more than twice the thickness in adult forms; periphery acute, with keel, not lobulate; chambers distinct, 12 to 15 in last-formed coil; sutures distinct, raised into heavy surface ridges, curved, entire space between sutures occupied by five to seven distinct retral processes; aperture consisting of a row of small openings along the base of the apertural face. Diameter, 0.35 mm.; thickness, 0.15 mm.

Young individuals of this form are completely involute, the inner margins of the chambers forming an umbo which determines the maximum thickness of the test; later coils do not cover the initial umbo, hence the greater proportion of diameter to thickness in adult forms. The umbo itself is variable, sometimes covered by a smooth deposit of clear shell material, sometimes exhibiting a varying number of spirally arranged pits, or in some cases being almost completely obscured by a spiral ridge formed by the fusion of the inner margins of the chambers.

This variety differs from the typical in its lesser number of chambers and in its smaller size. Its occurrence is rare but consistent throughout Zones I and II.

Type locality.—Tropical Oil Company No. 34974.

Holotype.—AMNH, Cat. no. FT-1102.

Family HETEROHELICIDAE
Genus PLECTOFRONDICULARIA
Liebus, 1902
PLECTOFRONDICULARIA FLORIDANA
Cushman
Plate 75, figures 1a, b

Plectofrondicularia floridana CUSHMAN, 1930, Florida Geol. Survey, Bull. 4, p. 41, pl. 8, fig. 1; BERMUDEZ, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 175, pl. 11, fig. 42.

Rare fragments of this species are present in both zones.

Dimensions of figured specimen.—Length, 0.35 mm.; width, 0.17 mm.; thickness, 0.08 mm.

Plesiotype.—AMNH.

Family BULIMINIDAE
Genus BULIMINELLA Cushman, 1911
BULIMINELLA ELEGANTISSIMA
(d'Orbigny)
Plate 75, figure 2

Bulimina elegantissima D'ORBIGNY, 1839, Voyage dans l'Amérique Méridionale; Foraminifères, tome 5, pt. 5, p. 51, pl. 7, figs. 13, 14.
Buliminella elegantissima (d'Orbigny). CUSHMAN, 1919, U. S. Nat. Mus. Proc., vol. 56, no. 2302, p. 606; CUSHMAN & PARKER, 1947, U. S. Geol. Survey Prof. Paper 210-D, p. 67, pl. 17, figs. 10–12; BERMUDEZ, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 185, pl. 12, fig. 13.

This well known species is abundant in Zone I and rare in Zone II.

Dimensions of figured specimen.—Length, 0.35 mm.; diameter, 0.14 mm.

Plesiotype.—AMNH.

BULIMINELLA SUBFUSIFORMIS Cushman
Plate 75, figures 3a, b

Buliminella subfusiformis CUSHMAN, 1925, Cushman Lab. Foram. Research Contr., vol. 1, p. 33, pl. 5, fig. 12; CUSHMAN & PARKER, 1947, U. S. Geol. Survey Prof. Paper 210-D, p. 64, pl. 16, fig. 21.

Both zones contain rare specimens of this form.

Dimensions of figured specimen.—Length, 0.34 mm.; diameter, 0.17 mm.

Plesiotype—AMNH.

Genus BULIMINA d'Orbigny, 1826
BULIMINA MEXICANA Cushman
Plate 75, figure 4

Bulimina inflata Seguenza var. *mexicana* CUSHMAN, 1922, U. S. Nat. Mus., Bull. 104, pt. 3, p. 95, pl. 21, fig. 2.
Bulimina striata d'Orbigny var. *mexicana* Cushman. CUSHMAN & PARKER, 1940, Cushman Lab. Foram. Research Contr., vol. 16, p. 16, pl. 3, fig. 9; CUSHMAN & TODD, 1945, Cushman Lab. Foram. Research Special Pub. 15, p. 40, pl. 6, fig. 10; CUSHMAN & PARKER, 1947, U. S. Geol. Survey, Prof. Paper 210-D, p. 119, pl. 28, fig. 4.
Bulimina mexicana Cushman. BERMUDEZ, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 182, pl. 12, fig. 2.

There are a few specimens in Zone II which probably belong in this species although some of them are very close to the "*Bulimina inflata* Seguenza" figured by Cushman and Parker (1938, Cushman Lab. Foram. Research Contr., vol. 14, pl. 10, fig. 5) from the Pliocene of Messina, Sicily.

Dimensions of figured specimen.—Length, 0.45 mm.; width, 0.33 mm.

Plesiotype.—AMNH.

Genus ENTOSOLENIA Ehrenberg, 1848
ENTOSOLENIA ATLANTICA Redmond, n. sp.
Plate 75, figures 5a, b

Test variable in outline, ranging from nearly circular to elongate oval, compressed, periphery truncate, with a single broad, thin keel in the median line and short thick rounded ones at the angles, these subsidiary keels usually continuous around the bottom of the test and extending upward onto the broad, otherwise thin, neck to merge with a narrow flange which surrounds the aperture; the central part of the test framed by the secondary keels is clear and glassy, with irregularly disposed punctae which are usually confined to the central region; aperture terminal, narrowly elliptical, entosolenian tube of variable length and shape. Dimensions: length, 0.23 mm.; width, 0.20 mm.; thickness, 0.11 mm.

This species closely resembles *E. perforata* Moebius but differs in having its subsidiary keels continuous around the bottom or, at most, briefly interrupted instead of definitely separated and turned downward. *E. lacunata* (Burrows and Holland) [*Lagena lacunata*, 1895] has much the same arrangement of keels as *E. atlantica* but has large irregular pits on the surface in place of relatively fine perforations. *E. punctata* (Seguenza) [*Fissurina punctata*, 1880] and *E. marginato-perforata* (Seguenza)

[*Lagena marginato-perforata*, 1880] both lack the everted neck; and *E. punctata* (Allix) (not Seguenza) [*Fissurina punctata*, 1913] appears to be a single-keeled form.

All occurrences of this species are confined to Zone I where it is rare to common.

Type locality.—Tropical Oil Company No. 34953.

Holotype.—AMNH, Cat. no. FT-1103.

ENTOSOLENIA aff. E. ORBIGNYANA (Seguenza) var. FLINTII (Cushman)
Plate 75, figures 6a, b

See *Lagena orbignyana* (Seguenza) var. *flintii* CUSHMAN, 1922, U. S. Geol. Survey, Prof. Paper 129-F, p. 129, pl. 29, fig. 1.

Cushman remarks that his variety is very close to specimens from off the east coast of the United States figured by Flint (1899, p. 308, pl. 54, fig. 5) as *Lagena castrensis* Schwager. Unfortunately, this reference is not available to the writer, so the extent of similarity of the Tubara form to Flint's material cannot be stated.

One broken specimen was found in Zone II.

Dimensions of figured specimen.—Length, 0.29 mm.; width, 0.23 mm.

Plesiotype.—AMNH.

Genus VIRGULINA d'Orbigny, 1826
VIRGULINA PONTONI Cushman
Plate 75, figures 7a, b

Virgulina pontoni CUSHMAN, 1932, Cushman Lab. Foram. Research Contr., vol. 8, p. 17, pl. 3, fig. 7; KLEINPELL, 1938, Miocene Stratigraphy of California, p. 263; RENZ, 1948, Geol Soc. America Mem. 32, p. 178, pl. 6, fig. 18.

Rare and fragmentary specimens of this form are found in Zone I.

Dimensions of figured specimen.—Length, 0.42 mm.; width, 0.18 mm.; thickness, 0.10 mm.

Plesiotype.—AMNH.

Genus BOLIVINA d'Orbigny, 1839
BOLIVINA BREVIOR Cushman
Plate 75, figures 8a, b

Bolivina brevior CUSHMAN, 1925, Cushman Lab. Foram. Research Contr., vol. 1, p. 31, pl. 5, figs. 8a, b; BARBAT & JOHNSON, 1934, Jour. Paleontology, vol. 8, p. 15, pl. 1, fig. 18.

Two specimens of this minute form were found in Zone I. The lobes near the inner margins of the sutures mentioned by Barbat and Johnson in the text (but not shown on the figure) are present in one of the Tubara specimens.

Dimensions of figured specimen.—Length, 0.27 mm.; width, 0.12 mm.; thickness, 0.07 mm.

Plesiotype.—AMNH.

BOLIVINA IMPORCATA Cushman & Renz
Plate 75, figures 9a, b

Bolivina floridana Cushman var. *regularis* CUSHMAN & RENZ, 1941, Cushman Lab. Foram. Research Contr., vol. 17, p. 17, pl. 3, fig. 7.
Bolivina floridana imporcata CUSHMAN & RENZ, 1944, Cushman Lab. Foram. Research Contr., vol. 20, p. 78.
Bolivina imporcata Cushman and Renz. RENZ, 1948, Geol. Soc. America Mem. 32, p. 118, pl. 7, figs. 3a, b.

This form is typically developed but rare in both zones.

Dimensions of figured specimen.—Length, 0.43 mm.; width, 0.22 mm.; thickness, 0.17 mm.

Plesiotype.—AMNH.

BOLIVINA INTERJUNCTA Cushman
var. BICOSTATA Cushman
Plate 75, figures 10a, b

Bolivina costata d'Orbigny var. *bicostata* CUSHMAN, 1926, Cushman Lab. Foram. Research Contr., vol. 2, p. 42.
Bolivina interjuncta Cushman var. *bicostata* Cushman. CUSHMAN, 1937, Cushman Lab. Foram. Research Special Pub. 9, p. 116, pl. 22, fig. 23; BERMUDEZ, 1949, idem, Special Pub. 25, p. 191, pl. 12, fig. 24.

This variety is typical and abundant in both zones. A variant which was described as *Bolivina interjuncta* var. *simplex* by Cushman and Renz and later raised to specific rank by Renz is present but rare in both zones.

Dimensions of figured specimen.—Length, 0.50 mm.; width, 0.33 mm.; thickness (excluding costae), 0.12 mm.

Plesiotype.—AMNH.

BOLIVINA LIGULARIA Schwager
Plate 75, figures 11a, b

Bolivina ligularia SCHWAGER, 1866, Novara-Exped., Geol. Theil, Bd. 2, p. 255, pl. 7, fig. 102; CUSHMAN, 1937, Cushman Lab. Foram. Research Special Pub. 9, p. 114, pl. 14, figs. 3–5; CUSHMAN & TODD, 1945, idem, Special Pub. 15, p. 45, pl. 7, fig. 12.

A form which is very rare in both zones

corresponds closely to Schwager's figure and description of the above species.

Dimensions of figured specimen.—Length, 0.36 mm.; width, 0.15 mm.; thickness, 0.08 mm.

Plesiotype.—AMNH.

BOLIVINA MARGINATA Cushman
var. MULTICOSTATA Cushman
Plate 75, figures 12a, b

Bolivina aenariensis (Costa) var. *multicostata* CUSHMAN, 1918, U. S. Geol. Survey, Bull. 676, p. 48, pl. 10, fig. 2.
Bolivina marginata Cushman var. *multicostata* Cushman. CUSHMAN, 1930, Florida Geol. Survey, Bull. 4, p. 46, pl. 8, figs. 13, 14; CUSHMAN, 1937, Cushman Lab. Foram. Research Special Pub. 9, p. 87, pl. 10, figs. 7–10.

The costae in the Tubara forms are largely confined to the apical end, a development similar to that noted by Mrs. Palmer in the Bowden material. This species is rare in both zones and almost always poorly preserved.

Dimensions of figured specimen.—Length, 0.35 mm.; width, 0.23 mm.; thickness, 0.10 mm.

Plesiotype.—AMNH.

BOLIVINA PLICATELLA Cushman
Plate 75, figures 13a, b

Bolivina plicatella CUSHMAN, 1930, Florida Geol. Survey, Bull. 4, p. 46, pl. 8, figs. 10a, b; CUSHMAN & TODD, 1945, Cushman Lab. Foram. Research Special Pub. 15, p. 46, pl. 7, fig. 10.

Zone I contains rare but typical representatives of this species.

Dimensions of figured specimen.—Length, 0.29 mm.; width, 0.17 mm.; thickness, 0.08 mm.

Plesiotype.—AMNH.

BOLIVINA TORTUOSA (H. B. Brady)
Plate 75, figures 14a, b

Bulimina (*Bolivina*) *tortuosa* BRADY, 1881, Quart. Jour. Micr. Sci., vol. 21, p. 57.
Bolivina tortuosa (Brady). BRADY, 1884 (part), Rep. Voy. Challenger, Zool., vol. 9, p. 420, pl. 52, figs. 31, 32 (not figs. 33–34).
Bolivina tortuosa (Brady). CUSHMAN, 1937 (part), Cushman Lab. Foram. Research Special Pub. 9, p. 133, pl. 17, figs. 17–19 (not figs. 11–16).

Study of the figures given for *B. tortuosa* by Cushman in his monograph of the subfamily Virgulininae would suggest that two closely allied forms have been grouped under this species name. Brady notes that his typical form has chambers that are projecting and rounded at the free ends and also that the test is conspicuously perforated. Cushman, who saw Brady's type specimens, added that the test was short and broad with the aperture tending to become terminal. He also stated definitely that the periphery is acute but not carinate. It thus would appear, that of all the figures given by Cushman only the reproductions of Brady's 1884 figures and those of Cushman and Parker for a form from the east coast of South America could be considered as truly representative of this species.

Rare specimens from both Zone I and Zone II of the Tubara appear to be quite typical.

Dimensions of figured specimen.—Length, 0.30 mm.; width, 0.20 mm.

Plesiotype.—AMNH.

BOLIVINA TORTUOSA (H. B. Brady)
var. LISSA Redmond, n. var.
Plate 75, figures 15a, b

Bolivina tortuosa (Brady). CUSHMAN, 1937 (part), Cushman Lab. Foram. Research Special Pub. 9, p. 133, pl. 17, figs. 11–16 (not figs. 17–19); CUSHMAN & TODD, 1945, idem, Special Pub. 15, p. 44, pl. 7, fig. 6.

Variety differing from the typical in having a more slender, carinate test with the median line formed by the inner margins of the chambers staggered; shows tendency for last-formed chambers to be more triangular, diminishing in height toward the outer margin; wall more finely perforate and aperture less terminal. Dimensions: length, 0.30 mm.; width, 0.18 mm.

This variety is found only in Zone I where it is rare.

Type locality.—Tropical Oil Company No. 34959.

Holotype.—AMNH, Cat. no. FT-1104.

Genus LOXOSTOMUM Ehrenberg, 1854
LOXOSTOMUM LIMBATUM (Brady)
var. COSTULATUM (Cushman)
Plate 75, figures 16a, b

Bolivina limbata (Brady) var. *costulata* CUSHMAN, 1922, Carnegie Inst. Washington, Pub. 311, p. 26, pl. 3, fig. 8.
Loxostoma limbatum (Brady) var. *costulatum* (Cushman). CUSHMAN, 1937, Cushman Lab. Foram. Research Special Pub. 9, p. 187, pl. 21,

figs. 30, 31; PALMER, 1945, Bull. Amer. Paleontology, vol. 29, no. 115, p. 48.

Rare individuals of this variety are found in both zones. It is suspected that some of the Miocene records of *Bolivina arta* Macfadyen from the Caribbean area might stem from misidentification of the occasionally narrow, straight and regularly tapering specimens of this form.

Dimensions of figured specimen.—Length, 0.52 mm.; width, 0.25 mm.; thickness, 0.12 mm.

Plesiotype.—AMNH.

Genus BIFARINA Parker & Jones, 1872

BIFARINA HANCOCKI Cushman & McCulloch

Plate 75, figures 17a, b; 18a, b

Bifarina hancocki CUSHMAN & MCCULLOCH, 1942, Univ. Southern Calif. Pub., Allan Hancock Pacific Exped., vol. 6, no. 4, p. 225, pl. 28, figs. 13–19.

This species is confined to Zone I where it is abundant throughout. It is interesting to note that large, coarsely ornamented microspheric individuals predominate in the lower part of the zone and slender, more delicately ornamented megalospheric forms have the ascendancy in the upper part of the zone, though neither form is ever present to the exclusion of the other.

Dimensions of figured specimens.—Microspheric, figs. 17a, b; length of biserial portion, 0.35 mm.; width of biserial portion, 0.18 mm.; thickness of biserial portion, 0.13 mm.; over-all length, 0.45 mm. Megalospheric, figs. 18a, b; length of biserial portion, 0.25 mm.; width of biserial portion, 0.15 mm.; thickness of biserial portion, 0.10 mm.; over-all length, 0.37 mm.

Plesiotypes.—AMNH.

BIFARINA PACIFICA Cushman & McCulloch

Plate 75, figures 19a, b; 20a, b

Bifarina pacifica CUSHMAN & MCCULLOCH, 1942, Univ. Southern Calif. Pub., Allan Hancock Pacific Exped., vol. 6, no. 4, p. 225, pl. 28, fig. 20.

This distinctive form is found only in Zone II where it is rare to common.

Dimensions of figured specimens.—Microspheric (?), figs. 19a, b; length of biserial portion, 0.28 mm.; width of biserial portion, 0.13 mm.; thickness of biserial portion, 0.075 mm.; over-all length, 0.38 mm. Megalospheric (?), figs. 20a, b; length of biserial portion, 0.18 mm.; width of biserial portion, 0.12 mm.; thickness of biserial portion, 0.075 mm.; over-all length, 0.37 mm.

Plesiotypes.—AMNH.

Genus RECTOBOLIVINA Cushman, 1927

RECTOBOLIVINA PAUCICOSTATA (Cushman & Todd)

Plate 75, figures 21a, b

Siphogenerina paucicostata CUSHMAN & TODD, 1945, Cushman Lab. Foram. Research Special Pub. 15, p. 52, pl. 7, fig. 34.

This species is confined to Zone II where it is extremely rare. It was placed in *Rectobolivina* because of its compressed biserial initial portion and because of the fact that somewhat larger specimens seen elsewhere show the central depressed area so typical of this genus.

Dimensions of figured specimen.—Length, 0.38 mm.; width, 0.125 mm.

Plesiotype.—AMNH.

Genus REUSSELLA Galloway, 1933

REUSSELLA BORDATA Redmond, n. sp.

Plate 75, figures 22a, b

Test averaging about twice as long as broad, triangular in transverse section with the sides ranging from nearly flat to moderately concave, base acute, usually with a short spine, angles sharp, bordered by narrow keels; chambers distinct, not inflated; sutures limbate, flush, only slightly curved; wall smooth, central portion of each chamber clear and glassy and with extremely minute perforations, lower and outer margin of each chamber marked by single row of closely-set prominent pores; aperture obscure on all specimens but appears to be a very small opening at the inner margin of last-formed chamber. Length, 0.48 mm.; width, 0.26 mm.

This distinctive species is abundant in both zones of the Tubara.

Type locality.—Tropical Oil Company No. 34976.

Holotype.—AMNH, Cat. no. FT-1105.

REUSSELLA MIOCENICA Cushman

Plate 75, figures 23a, b

Reussella miocenica CUSHMAN, 1945, Cushman Lab. Foram. Research Contr., vol. 21, p. 36, pl. 6, figs. 19, 20.

The Tubara specimens are very variable

as to size and shape and only rarely develop spines of the magnitude shown on Cushman's figure. Otherwise, they closely match the written description of this species.

Very few specimens of this form were encountered and those were confined to Tropical Oil Company Sample No. 34976 near the top of Zone II.

Dimensions of figured specimen.—Length, 0.43 mm.; width, 0.20 mm.

Plesiotype.—AMNH.

REUSSELLA PULCHRA Cushman
Plate 75, figures 24a, b

Reussella pulchra CUSHMAN, 1945, Cushman Lab. Foram. Research Contr., vol. 21, p. 34, pl. 6, figs. 11, 12.

This species is common and typically developed in both zones.

Dimensions of figured specimen.—Length, 0.29 mm.; width, 0.21 mm.

Plesiotype.—AMNH.

Genus PAVONINA d'Orbigny, 1826

PAVONINA cf. P. MIOCENICA
Cushman & Ponton
Plate 75, figure 25

Pavonina miocenica CUSHMAN & PONTON, 1932, Florida Geol. Survey, Bull. 9, p. 73, pl. 12, fig. 19a, b.

A single specimen found in Tropical Oil Company Sample No. 34974 in Zone II is close in general form to Cushman and Ponton's Choctawhatchee species. It differs, however, in having the septa either raised or broken into a series of closely-spaced beads.

Dimensions of figured specimen.—Length, 0.48 mm.; width, 0.56 mm.; thickness, 0.09 mm.

Plesiotype.—AMNH.

Genus UVIGERINA d'Orbigny, 1826

UVIGERINA ISIDROENSIS Cushman & Renz
Plate 75, figures 26a, b

Uvigerina isidroensis CUSHMAN & RENZ, 1941, Cushman Lab. Foram. Research Contr., vol. 17, p. 20, pl. 3, fig. 16.

Rare and poorly preserved specimens of this form are present in both zones.

Dimensions of figured specimen.—Length, 0.38 mm.; width, 0.26 mm.

Plesiotype.—AMNH.

UVIGERINA PEREGRINA Cushman
Plate 75, figures 27a, b

Uvigerina peregrina CUSHMAN, 1923, U. S. Nat. Mus., Bull. 104, pt. 4, p. 166, pl. 42, figs. 7–10; CUSHMAN & PONTON, 1932, Florida Geol. Survey, Bull. 9, p. 85.

This species is rare in both zones.

Dimensions of figured specimen.—Length, 0.47 mm.; width, 0.23 mm.

Plesiotype.—AMNH.

Genus ANGULOGERINA Cushman, 1927

ANGULOGERINA COLOMBIANA
Redmond, n. sp.
Plate 75, figures 28a, b

Test elongate, fusiform, a little over twice as long as broad, initial portion rounded in section, later portion triangular, becoming definitely carinate in some specimens; chambers distinct, moderately inflated, later chambers becoming triangular in section; sutures distinct, depressed; wall smooth, very finely perforate; aperture broadly oval with a very slight lip. Length, 0.38 mm.; diameter, 0.18 mm.

This species is close to *Angulogerina hughesi* (Galloway and Wissler) in general form but differs from the latter in the lack of occasional development of costae on the apical end and in the appearance of the triangular stage at an earlier point in the development of the test.

Both zones contain occasional abundances of this species.

Type locality.—Tropical Oil Company No. 34968.

Holotype.—AMNH, Cat. no. FT-1106.

ANGULOGERINA JAMAICENSIS Cushman & Todd
Plate 75, figures 29a, b

Angulogerina jamaicensis CUSHMAN & TODD, 1945, Cushman Lab. Foram. Research Special Pub. 15, p. 53, pl. 8, fig. 3.

This species is abundant in Zone I and rare to common in Zone II.

Dimensions of figured specimen.—Length, 0.35 mm.; diameter, 0.15 mm.

Plesiotype.—AMNH.

Genus COMPRESSIGERINA Bermudez, 1949

COMPRESSIGERINA COARTATA (Palmer)
Plate 75, figures 30a, b

Uvigerina compressa PALMER, 1941, Mem. Soc.

Cubana Hist. Nat., vol. 15, p. 182, pl. 15, figs. 10, 11 (not *Uvigerina compressa* Cushman, 1925).

Uvigerina coartata PALMER (new name), 1941, idem, vol. 15, p. 304.

Bolivina(?) *distorqueata* CUSHMAN & TODD, 1945, Cushman Lab. Foram. Research Special Pub. 15, p. 45, pl. 7, fig. 11.

Compressigerina coartata (Palmer). BERMUDEZ, 1949, idem, Special Pub. 25, p. 220, pl. 13, figs. 71–74.

This distinctive little form has been found only in Zone II of the Tubara material. It is rare but consistently present throughout the zone.

Dimensions of figured specimen.—Length, 0.21 mm.; width, 0.22 mm.

Plesiotype.—AMNH.

Family ROTALIIDAE
Genus SPIRILLINA Ehrenberg, 1843
SPIRILLINA LIMBATA H. B. Brady var. DENTICULATA H. B. Brady (*fide* Cushman)
Plate 75, figure 31

Spirillina limbata Brady var. *denticulata* Brady. CUSHMAN, 1931 (part), U. S. Nat. Mus., Bull. 104, pt. 8, p. 8, pl. 2, fig. 5 (not fig. 4).

Zone II contains several specimens which appear to be identical with the form from the Belgian coast figured by Cushman as *Spirillina limbata denticulata.*

Dimensions of figured specimen.—Diameter, 0.42 mm.; thickness, 0.10 mm.

Pleisotype.—AMNH.

Genus DISCORBIS Lamarck, 1804
DISCORBIS FLORIDANUS Cushman
Plate 76, figures 1a–c

Discorbis floridana CUSHMAN, 1922, Carnegie Inst. Washington, Pub. 311, p. 39, pl. 5, figs. 11, 12; 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 21, pl. 4, figs. 7, 8; BERMUDEZ, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 238, pl. 15, figs. 16–18.

Several of the Tubara specimens have a ventral aspect similar to the individual figured by Cushman in 1931, but the majority are closer to figure 12 of the original publication. This species is confined to Zone II where it is rare and encountered mostly in the upper beds.

Dimensions of figured specimen.—Diameter, 0.25 mm.; height, 0.08 mm.

Plesiotype.—AMNH.

DISCORBIS FLORIDENSIS Cushman
Plate 75, figures 32a–c

Discorbis bertheloti (d'Orbigny) var. *floridensis* CUSHMAN, MS., 1930, in Cushman and Jarvis, Jour. Paleontology, vol. 4, p. 364, pl. 33, figs. 13a–c; CUSHMAN & TODD, 1945, Cushman Lab. Foram. Research Special Pub. 15, p. 56, pl. 8, figs. 15, 16.

Discorbis floridensis Cushman. BERMUDEZ, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 238, pl. 15, figs. 19–21.

Specimens which are close to Cushman and Todd's 1945 figure are rare to common in the lower part of Zone II. As noted by Mrs. Palmer (1945, p. 55) in speaking of the Bowden specimens, the sutures are more broadly limbate and elevated than indicated in the original figure and description and the test is more convex dorsally.

Dimensions of figured specimen.—Diameter, 0.28 mm.; height, 0.08 mm.

Plesiotype.—AMNH.

DISCORBIS TERQUEMI (Rzehak)
Plate 76, figures 2a–c

Rosalina orbicularis TERQUEM, 1876, Essai sur le classement des animaux qui vivent sur la plage et dans les environs de Dunkerque; Deuxième fascicule, p. 75, pl. 1, figs. 4a, b (not *Rosalina orbicularis* d'Orbigny, 1850).

Discorbis orbicularis (Terquem). CUSHMAN, 1919, Carnegie Inst. Washington, Pub. 291, p. 40; 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 27, pl. 6, figs. 3a–c; PALMER, 1945, Bull. Amer. Paleontology, vol. 29, no. 115, p. 56; BERMUDEZ, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 239, pl. 15, figs. 31–33.

Discorbina terquemi Rzehak (new name), 1888, Austria, Geol. Reichsanst. Verh., no. 11, p. 228.

This species is confined to Zone I where it is common.

Dimensions of figured specimen.—Diameter, 0.25 mm.; height, 0.08 mm.

Plesiotype.—AMNH.

Genus GAVELINOPSIS Hofker, 1951
GAVELINOPSIS WOODRINGI Redmond, n. sp.
Plate 76, figures 3a–c

Test small, plano-convex, outline circular to oblong, two whorls visible on dorsal side, ventral side usually with one whorl visible but sometimes with final chamber not completely covering underlying chambers of preceding whorl, ventrally umbilicate with umbilicular cavity wholly or partly filled with stud of clear shell material; margin entire, carinate; chambers distinct, rapidly

increasing in size, with final chamber constituting up to a third of ventral side of test, flush on dorsal side, slightly inflated on ventral side and often projecting into lobes on umbilical margin; sutures distinct, depressed ventrally, limbate and flush dorsally; wall smooth, inconspicuously perforate on ventral side, conspicuously but finely perforate on dorsal side; aperture a low arch at the base of the umbilical margin of the last chamber, usually with a slight, thin lip. Diameter 0.33 mm.; thickness, 0.10 mm.

This species differs from *G. praegeri* (Heron-Allen and Earland) in having fewer whorls, being more conspicuously carinate and in showing less tendency toward a lobulate periphery.

Gavelinopsis woodringi is common in both zones of the Tubara.

Type locality.—Tropical Oil Company No. 34972.

Holotype.—AMNH, Cat. no. FT-1107.

Genus GLABRATELLA Dorreen, 1948

GLABRATELLA BROWNINGI Redmond, n. sp.

Plate 76, figures 4a–c

Test small, dorsal side evenly convex, ventral side concave, periphery rounded, slightly lobulate, about two whorls visible dorsally, only last whorl visible ventrally; chambers slightly inflated, rapidly increasing in size, four in last whorl; sutures depressed, obscure in some specimens; wall moderately coarsely perforate and in some specimens granular on dorsal side, more finely perforate, smooth and striate radially on ventral side; aperture appears to be a low arch on inner face of last-formed chamber, opening into prominent vestibule which is partially closed by thin platy extensions of inner margins of chambers. Diameter, 0.20 mm.; height, 0.11 mm.

In all, only six specimens of this form were found; one specimen was encountered in the upper part of Zone I and the remainder were found in Zone II.

Type locality.—Tropical Oil Company No. 34972.

Holotype.—AMNH, Cat. no. FT-1108.

Genus VALVULINERIA Cushman, 1926

VALVULINERIA OLSSONI Redmond, n. sp.

Plate 76, figures 5a–c

Test unequally biconvex, dorsal side higher and somewhat evolute, often with two whorls visible, ventral side completely involute; periphery bluntly angled on final chambers, subcarinate on earlier portion of test; chambers distinct, the later ones showing a slight tendency toward inflation, about seven in the last whorl; sutures distinct, limbate, curved, raised in initial portion of dorsal side and becoming slightly depressed in final portion, flush in initial portion of ventral side, becoming slightly depressed in final portion; wall very finely perforate; aperture ventral, a low slit extending from the umbilicus nearly to the periphery and covered by a plate-like extension of the inner margin of the final chamber. Diameter, 0.37 mm.; thickness, 0.12 mm.

This species is rare in both zones.

Type locality.—Tropical Oil Company No. 34972.

Holotype.—AMNH, Cat. No. FT-1109.

Genus EPONIDES Montfort, 1808

"EPONIDES" LATERALIS (Terquem)

Plate 76, figures 6a–c

Rosalina lateralis TERQUEM, 1878, Soc. Géol. France, Mém., sér. 3, tome 1, no. 3, p. 25, pl. 2, figs. 11a–c.

Eponides lateralis (Terquem). CUSHMAN, 1930, Florida Geol. Survey, Bull. 4, p. 55, pl. 10, figs. 7a–c; 1931 (as *Eponides(?) lateralis*), U. S. Nat. Mus., Bull. 104, pt. 8, p. 47, pl. 10, figs. 5a–c.

It is probable that this form is no more than a variant of "*Eponides repandus*" (Brady, not Fichtel and Moll). However, as it is listed in the literature from beds for which there is no record of the typical form, it has been kept separate here. It is very rare in both Tubara zones.

Dimensions of figured specimen.—Diameter, 0.65 mm.; thickness, 0.25 mm.

Plesiotype.—AMNH.

"EPONIDES" PARANTILLARUM

Galloway & Heminway

Plate 76, figures 7a–c

Eponides antillarum (d'Orbigny). CUSHMAN & JARVIS, 1930, Jour. Paleontology, vol. 4, p. 364, pl. 33, fig. 14; pl. 34, fig. 2.

Eponides parantillarum GALLOWAY & HEMINWAY, 1941, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Ids., vol. 3, pt. 4, p. 374, pl. 18, fig. 1; BERMUDEZ, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 247, pl. 16, figs. 49–51.

Typically developed representatives of

this species are present but rare in both zones. The figured specimen is an individual with more than normally curved ventral sutures.

Dimensions of figured specimen.—Diameter, 0.55 mm.; height, 0.28 mm.

Plesiotype.—AMNH.

"EPONIDES REPANDUS" (Brady, not Fichtel & Moll)
Plate 76, figures 8a–c

Pulvinulina repanda (Fichtel & Moll). BRADY, 1884, Rep. Voy. Challenger, Zool., vol. 9, p. 684, pl. 104, figs. 18a–c.

Eponides repanda (Fichtel & Moll). CUSHMAN, 1929, U. S. Nat. Mus., Proc., vol. 75, art. 25, p. 11, pl. 4, figs. 7a–c.

Eponides repandus (Fichtel & Moll). CUSHMAN & PONTON, 1932, Florida Geol. Survey, Bull. 9, p. 92, pl. 13, figs. 9a–c; BERMUDEZ, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 248, pl. 17, figs. 13–15.

Individuals resembling those figured by both Cushman and Brady are common in both zones.

Dimensions of figured specimen.—Diameter, 0.65 mm.; thickness, 0.32 mm.

Plesiotype.—AMNH.

Genus ROTALIA Lamarck, 1804
ROTALIA ANDERSONI Redmond, n. sp.
Plate 76, figures 9a–c

Test biconvex, the ventral side usually more strongly convex than the dorsal, about two and one-half whorls visible dorsally; periphery lobulate, angled to slightly carinate, inner ends of chambers on ventral side extended to form inconspicuous plug; chambers distinct, inflated ventrally, eight or nine in last-formed whorl; sutures limbate and flush or slightly depressed dorsally, strongly depressed ventrally and furnished with extremely minute retral processes; wall smooth; aperture a low arch at the base of the apertural face about midway between umbilicus and periphery, sometimes with what appear to be supplementary openings near outer margins of chambers, also occasionally with a row of pores more or less in plane of coiling on apertural face. Diameter, 0.35 mm.; height, 0.13 mm.

When the secondary characteristics of this species are fully developed it represents an isomorph of the genus *Elphidioides* Cushman. It is found only in Zone I where it is common.

Type locality.—Tropical Oil Company No. 34962.

Holotype.—AMNH, Cat. No. FT-1110.

ROTALIA BECCARII (Linné)
Plate 76, figures 10a–c

Rotalia beccarii (Linné). CUSHMAN, 1928, Cushman Lab. Foram. Research Contr., vol. 4, pp. 103–107, pl. 15, figs. 1–7; 1931, U. S. Nat. Mus., Bull. 104, pt. 8, pp. 58–60, pl. 12, figs. 1–7; pl. 13, figs. 1, 2.

The Tubara form is small, but in all other respects seems to represent typical *R. beccarii*. It is abundant in both zones.

Dimensions of figured specimen.—Diameter, 0.33 mm.; thickness, 0.17 mm.

Plesiotype.—AMNH.

ROTALIA SARMIENTOI Redmond, n. sp.
Plate 76, figures 11a–c

Test small, equally biconvex, two whorls visible dorsally; periphery slightly lobulate, angled and furnished with a slight keel; umbonal area with a distinct, irregular and apparently porous plug; chambers distinct, dorsally flush, ventrally inflated and separated at their inner ends, seven to nine visible in the last-formed whorl; dorsal sutures limbate and raised, ventral sutures depressed and obscure; wall finely perforate and minutely roughened so that surface of test has frosted appearance; aperture an arched slit at the base of the apertural face about midway between umbilicus and periphery. Diameter, 0.30 mm.; height, 0.15 mm.

This species is rare in Zone I and very rare in Zone II.

Type locality.—Tropical Oil Company No. 34969.

Holotype.—AMNH, Cat. No. FT-1111.

Genus SIPHONINA Reuss, 1850
SIPHONINA PULCHRA Cushman
Plate 76, figures 12a–c

Siphonina pulchra CUSHMAN, 1919, Carnegie Inst. Washington, Pub. 291, p. 42, pl. 14, figs. 7a–c; CUSHMAN & TODD, 1945, Cushman Lab. Foram. Research Special Pub. 15, p. 59, pl. 9, fig. 12; BERMUDEZ, 1949, idem, Special Pub. 25, p. 243, pl. 16, figs. 34–36.

This species is very rare in both zones.

Dimensions of figured specimen.—Diameter, 0.31 mm.; thickness, 0.15 mm.

Plesiotype.—AMNH.

Genus CANCRIS Montfort, 1808
CANCRIS SAGRA (d'Orbigny)
Plate 76, figures 13a, b

Rotalina sagra D'ORBIGNY, 1839, in Ramon de la Sagra, Histoire physique, politique et naturelle de l'Île de Cuba; Foraminifères, p. 77, pl. 5, figs. 13–15.
Cancris sagra (d'Orbigny). CUSHMAN, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 74, pl. 15, figs. 2a–c; PALMER, 1945, Bull. Amer. Paleontology, vol. 29, no. 115, p. 62; BERMUDEZ, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 256, pl. 18, figs. 28–30.

Very rare specimens of this form are found in both zones.

Dimensions of figured specimen.—Length, 0.42 mm.; width, 0.30 mm.; thickness, 0.13 mm.

Plesiotype.—AMNH.

Family AMPHISTEGINIDAE
Genus ASTERIGERINA d'Orbigny, 1839
ASTERIGERINA CARINATA d'Orbigny
Plate 76, figures 14a–c

Asterigerina carinata D'ORBIGNY, 1839, in Ramon de la Sagra, Histoire physique, politique et naturelle de l'Île de Cuba; Foraminifères, p. 118, pl. 5, fig. 25; pl. 6, figs. 1, 2; PALMER, 1945, Bull. Amer. Paleontology, vol. 29, no. 115, p. 62; BERMUDEZ, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 265, pl. 19, figs. 31–33.

Very rare specimens closely resembling d'Orbigny's figure are encountered in Zone II.

Dimensions of figured specimen.—Diameter, 0.44 mm.; height, 0.21 mm.

Plesiotype.—AMNH.

ASTERIGERINA PETTERSI Redmond, n. sp.
Plate 76, figures 15a–c

Test small, plano-convex, ventral side flat or very slightly convex, dorsal side moderately convex, periphery acute with definite keel, the latter very finely perforate on the dorsal side, falsely giving the impression of very fine fluting on the ventral side, an illusion which is caused by the fact that the dorsal perforations extend inward radially as fine thread-like tunnels parallel to the ventral side of the keel; chambers distinct, five in the last-formed coil, ventrally with roughly triangular supplementary chambers extending from one-half to two-thirds the distance to the periphery giving a stellate appearance to the base of the test; sutures curved, flush and limbate on dorsal side, very slightly depressed on ventral side; wall finely perforate; aperture ventral, apparently a very small circular opening under an arched overhang near the inner margin of the base of the last-formed chamber. Diameter, 0.36 mm.; height, 0.16 mm.

This species belongs to the type represented by *A. bracteata* Cushman, from the lower Oligocene of Mississippi, and *A. planorbis* d'Orbigny, from the upper middle Miocene of the Vienna Basin, both of those forms being convex dorsally and nearly flat ventrally.

A. pettersi is common in both zones of the Tubara formation.

Type locality.—Tropical Oil Company No. 34973.

Holotype.—AMNH, Cat. No. FT-1112.

Genus AMPHISTEGINA d'Orbigny, 1826
AMPHISTEGINA ANGULATA (Cushman)
Plate 76, figures 16a–c

Asterigerina angulata CUSHMAN, 1919, Carnegie Instit. Washington, Pub. 291, p. 45, pl. 13, figs. 1a, b, c.
Amphistegina angulata (Cushman). CORYELL & RIVERO, 1940, Jour. Paleontology, vol. 14, p. 339; PALMER, 1945, Bull. Amer. Paleontology, vol. 29, no. 115, p. 63, pl. 2, figs. 2a–c; BERMUDEZ, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 261, pl. 19, figs. 19–21.

This species is found only in Zone II where it is extremely rare. No adult individuals were found.

Dimensions of figured specimen.—Diameter, 0.84 mm.; height, 0.55 mm.

Plesiotype.—AMNH.

AMPHISTEGINA LESSONII d'Orbigny
Plate 77, figures 1a–c

Amphistegina lessonii D'ORBIGNY, 1826, Ann. Sci. Nat., sér. 1, tome 7, p. 304, pl. 17, figs. 1–4 (*quoii* in description of plate); Modèles, no. 98, 1826; CUSHMAN, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 79, pl. 16, figs. 1–3; CUSHMAN & TODD, 1945, Cushman Lab. Foram. Research Special Pub. 15, p. 60, pl. 10, fig. 2; BERMUDEZ, 1949, idem, Special Pub. 25, p. 263, pl. 19, figs. 1–3.

Forms which fall within the wide range of variation ascribed to this species are sporadically abundant in Zone I and represented to a lesser extent in Zone II. The figured specimen is from Zone I.

Dimensions of figured specimen.—Diameter, 1.59 mm.; thickness, 0.63 mm.

Plesiotype.—AMNH.

AMPHISTEGINA LESSONII d'Orbigny
var. BOWDENENSIS Palmer
Plate 77, figures 2a–c

Amphistegina lessonii bowdenensis PALMER, 1945, Bull. Amer. Paleontology, vol. 29, no. 115, p. 64, pl. 2, figs. 1a–c.

Zone II carries a fairly common *Amphistegina* which appears to represent the variety described from the Bowden. The same form probably occurs in the upper part of Zone I, but the material is rather scanty and the distinction from the typical variety not too clear.

Dimensions of figured specimen.—Diameter, 1.59 mm.; thickness, 0.50 mm.

Plesiotype.—AMNH.

Family CYMBALOPORIDAE
Genus CYMBALOPORETTA Cushman, 1928
CYMBALOPORETTA BRADYI (Cushman)
Plate 77, figures 3a–c

Cymbalopora poeyi (d'Orbigny) var. *bradyi* CUSHMAN, 1915, U. S. Nat. Mus., Bull. 71, pt. 5, p. 25, pl. 10, figs. 2a–c; pl. 14, figs. 2a–c.
Cymbaloporetta bradyi (Cushman). CUSHMAN, 1931, idem, Bull. 104, pt. 8, p. 85.

This species is common in the lower part of Zone II. Dorsally it resembles *C. squammosa* from the overlying beds but ventrally shows as many as 10 relatively straight chambers of the type illustrated by Cushman in his 1915 figures.

Dimensions of figured specimen.—Diameter, 0.37 mm.; height, 0.13 mm.

Plesiotype.—AMNH.

CYMBALOPORETTA SQUAMMOSA (d'Orbigny)
Plate 77, figures 4a–c

Rosalina squammosa D'ORBIGNY, 1839, in Ramon de la Sagra, Histoire physique, politique et naturelle de l'Île de Cuba; Foraminifères, p. 91, pl. 3, figs. 12–14.
Rosalina poeyi D'ORBIGNY, 1839, idem, p. 92, pl. 3, figs. 18–20.
Cymbaloporetta squammosa (d'Orbigny). CUSHMAN, 1928, Cushman Lab. Foram. Research Contr., vol. 4, p. 7; 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 83, pl. 16, figs. 4a–c; BERMUDEZ, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 266, pl. 19, figs. 40–42.

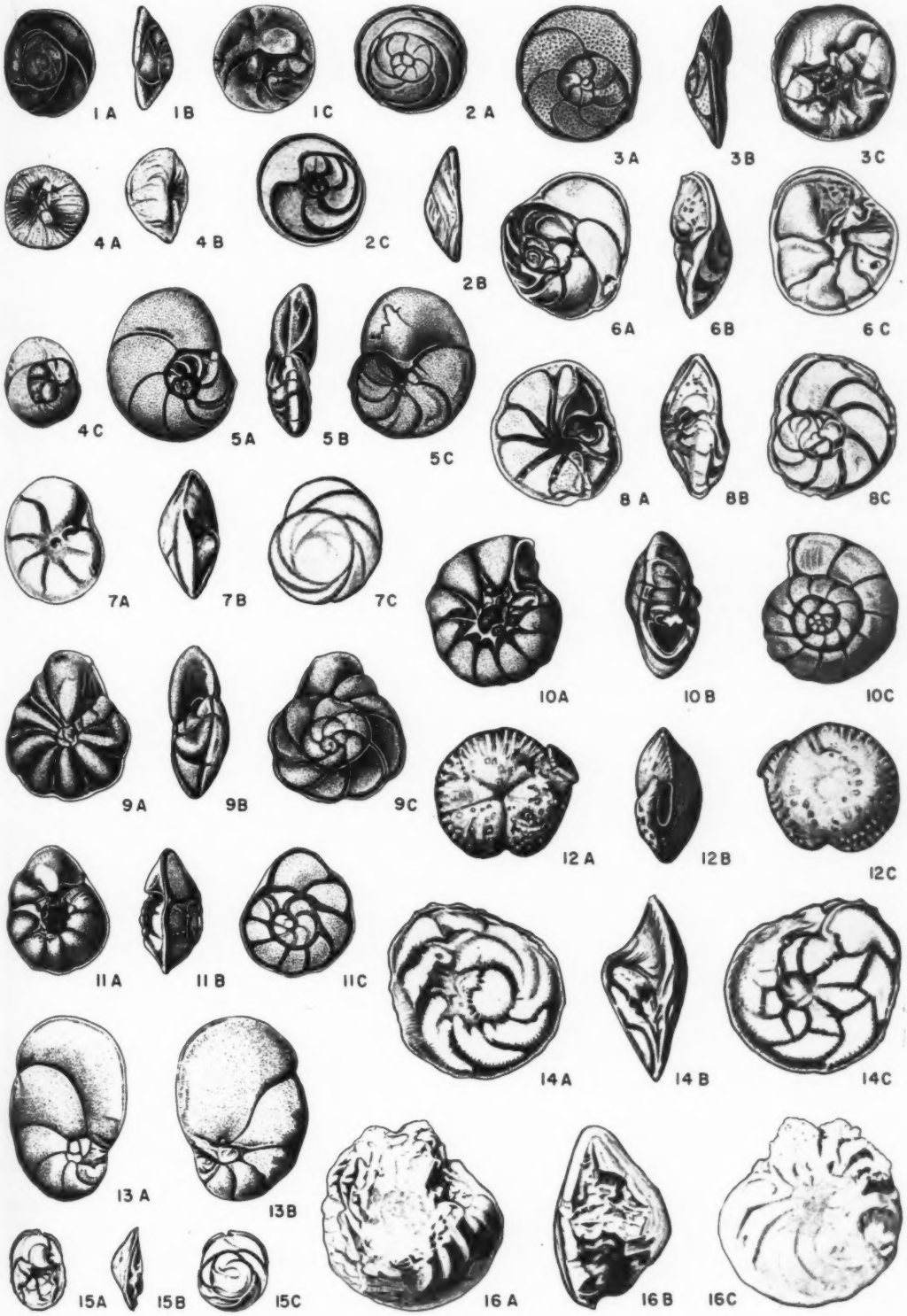
The upper part of Zone II contains common specimens of a low-spired *Cymbaloporetta* of the type described by d'Orbigny as *Rosalina poeyi* and later put into synonymy with *Rosalina squammosa* by Cushman under the genus *Cymbaloporetta*. The Tubara forms show about seven chambers on the ventral side, each with a marked constriction about one third of the way in from the periphery.

Dimensions of figured specimen.—Diameter, 0.43 mm.; height, 0.21 mm.

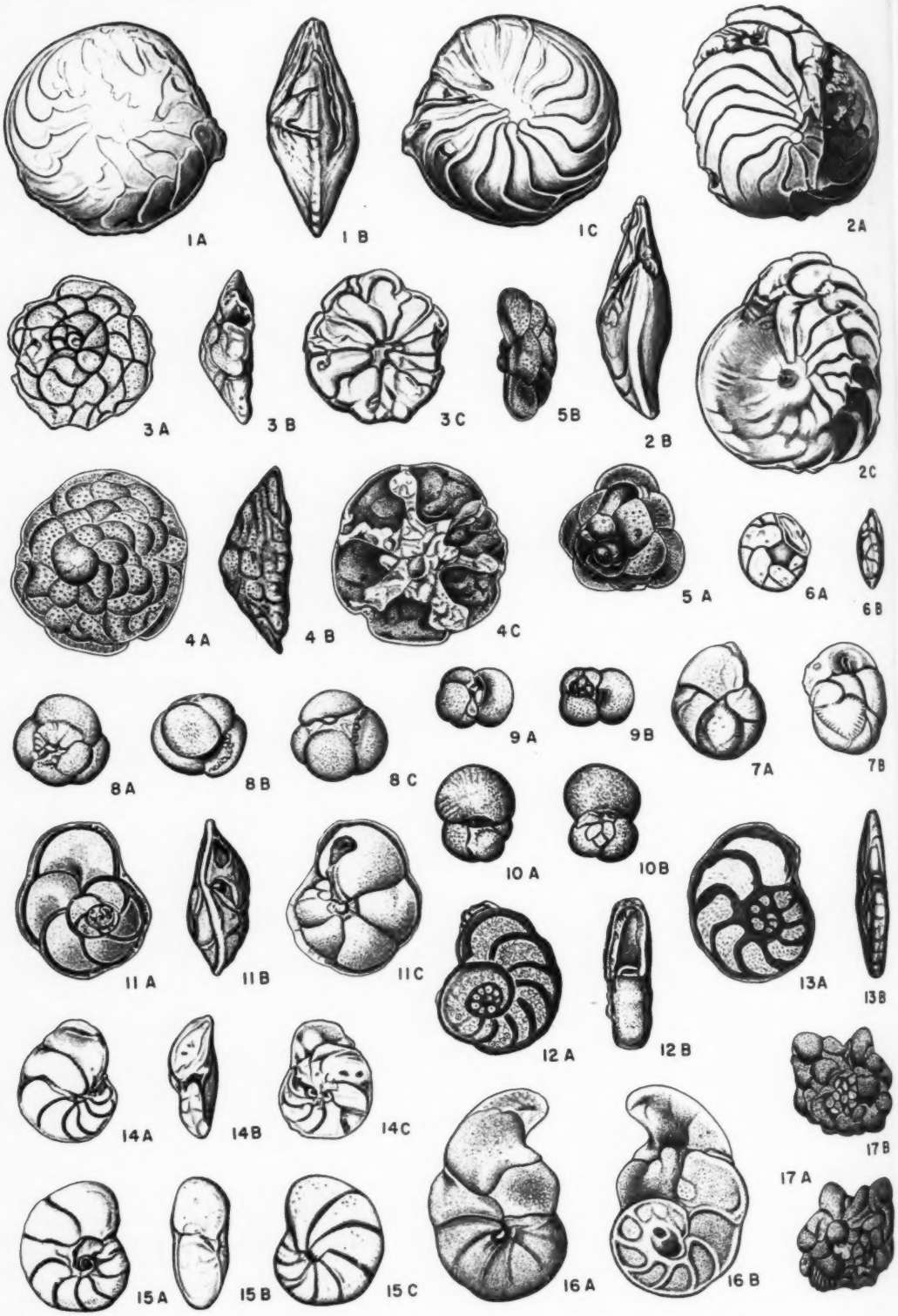
Plesiotype.—AMNH.

EXPLANATION OF PLATE 76

FIG. *1*—*Discorbis floridanus* Cushman. ×66. *a*, Dorsal view; *b*, edge view; *c*, ventral view. (p. 724)
2—*Discorbis terquemi* (Rzehak). ×68. *a*, Dorsal view; *b*, edge view; *c*, ventral view. (p. 724)
3—*Gavelinopsis woodringi* Redmond, n. sp. Holotype, ×60. *a*, Dorsal view; *b*, edge view; *c*, ventral view. (p. 724)
4—*Glabratella browningi* Redmond, n. sp. Holotype, ×70. *a*, Ventral view; *b*, edge view; *c*, dorsal view. (p. 725)
5—*Valvulineria olssoni* Redmond, n. sp. Holotype, ×61. *a*, Dorsal view; *b*, edge view; *c*, ventral view. (p. 725)
6—"*Eponides*" *lateralis* (Terquem). ×33. *a*, Dorsal view; *b*, edge view; *c*, ventral view. (p. 725)
7—"*Eponides*" *parantillarum* Galloway & Heminway. ×34. *a*, Ventral view; *b*, edge view; *c*, dorsal view. (p. 725)
8—"*Eponides repandus*" (Brady, not Fichtel & Moll). ×33. *a*, Ventral view; *b*, edge view; *c*, dorsal view. (p. 726)
9—*Rotalia andersoni* Redmond, n. sp. Holotype, ×63. *a*, Ventral view; *b*, edge view; *c*, dorsal view. (p. 726)
10—*Rotalia beccarii* (Linnaeus). ×67. *a*, Ventral view; *b*, edge view; *c*, dorsal view. (p. 726)
11—*Rotalia sarmientoi* Redmond, n. sp. Holotype, ×63. *a*, Ventral view; *b*, edge view; *c*, dorsal view. (p. 726)
12—*Siphonina pulchra* Cushman. ×64. *a*, Ventral view; *b*, edge view; *c*, dorsal view. (p. 726)
13—*Cancris sagra* (d'Orbigny). ×65. *a*, Dorsal view; *b*, ventral view. (p. 727)
14—*Asterigerina carinata* d'Orbigny. ×63. *a*, Dorsal view; *b*, edge view; *c*, ventral view. (p. 727)
15—*Asterigerina pettersi* Redmond, n. sp. Holotype, ×33. *a*, Ventral view; *b*, edge view; *c*, dorsal view. (p. 727)
16—*Amphistegina angulata* Cushman. ×33. *a*, Ventral view; *b*, edge view; *c*, dorsal view. (p. 727)



Redmond, Miocene Tubara Foraminifera, Colombia



Redmond, Miocene Tubara Foraminifera, Colombia

Genus TRETOMPHALUS Moebius, 1880

TRETOMPHALUS PACIFICUS Cushman

Plate 77, figures 5a, b

Tretomphalus pacificus CUSHMAN, 1934, Cushman Lab. Foram. Research Contr., vol. 10, p. 93, pl. 11, fig. 7; pl. 12, figs. 8–12.

A small form with the later chambers arranged in a series of three is present in the upper beds of Zone II. One specimen in the Tropical Oil Company collection shows vestiges of a crushed finely perforate float chamber.

Dimensions of figured specimen.—Diameter, 0.31 mm.; height, 0.13 mm.

Plesiotype.—AMNH.

Family CASSIDULINIDAE

Genus CASSIDULINA d'Orbigny, 1826

CASSIDULINA CARIBEANA Redmond, n. sp.

Plate 77, figures 6a, b

Cassidulina laevigata d'Orbigny var. *carinata* Cushman. CUSHMAN & TODD, 1945, Cushman Lab. Foram. Research Special Pub. 15, p. 62, pl. 10, fig. 11; PALMER, 1945, Bull. Amer. Paleontology, vol. 29, no. 115, p. 66; BERMUDEZ, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 268, pl. 20, figs. 22–24.

Cassidulina laevigata d'Orbigny. RENZ, 1948, Geol. Soc. America, Mem. 32, p. 125, pl. 9, figs. 9a, b.

Test small, compressed, biconvex, periphery slightly lobulate, sharply angled, sometimes with a narrow keel; chambers distinct, four to five pairs in the last whorl, early chambers flat, later chambers slightly inflated; sutures distinct, slightly curved, slightly limbate, flush in early portion of test, slightly depressed in later portion; wall smooth, very finely perforate with stellate umbonal area of clear shell material; aperture elongate, narrow, at base of last chamber. Dimensions: diameter, 0.19 mm.; thickness, 0.08 mm.

This species is almost certainly the "*Cassidulina laevigata* d'Orbigny var. *carinata* Cushman" listed and figured by Cushman and Todd from the Buff Bay material and discussed under the same name in the Bowden fauna by Mrs. Palmer. Likewise, it appears to represent the form figured by Renz as "*Cassidulina laevigata* d'Orbigny" from beds of the Agua Salada group of Venezuela. It has been considered necessary to establish a new species for the Tubara form, for the following two reasons: first, it is the author's opinion that the form in question is not identical with Cushman's Recent material from off Florida, being smaller, slightly lobulate, and with a clear umbonal area; second, Cushman's varietal name is preoccupied, having been used by

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EXPLANATION OF PLATE 77

FIG. *1*—*Amphistegina lessonii* d'Orbigny. ×20. *a*, Dorsal view; *b*, edge view; *c*, ventral view. (p. 727)

2—*Amphistegina lessonii* d'Orbigny var. *bowdenensis* Palmer. ×21. *a*, Ventral view; *b*, edge view; *c*, dorsal view. (p. 728)

3—*Cymbaloporetta bradyi* (Cushman). ×64. *a*, Dorsal view; *b*, edge view; *c*, ventral view. (p. 728)

4—*Cymbaloporetta squammosa* (d'Orbigny). ×64. *a*, Dorsal view; *b*, edge view; *c*, ventral view. (p. 728)

5—*Tretomphalus pacificus* Cushman. ×62. *a*, Dorsal view; *b*, edge view. (p. 729)

6—*Cassidulina caribeana* Redmond, n. sp. Holotype, ×62. *a*, Side view; *b*, edge view. (p. 729)

7—*Cassidulina vestae* Redmond, n. sp. Holotype, ×61. *a*, Side view; *b*, edge view. (p. 730)

8—*Globigerina altispira* Cushman & Jarvis. ×34. *a*, Dorsal view; *b*, side view; *c*, ventral view. (p. 730)

9—*Globigerinoides ruber* (d'Orbigny). ×36. *a*, Side view; *b*, side view. (p. 730)

10—*Globigerinoides tricameratus* (Tolmachoff). ×34. *a*, Side view; *b*, side view. (p. 730)

11—*Globorotalia menardii* (d'Orbigny). ×65. *a*, Dorsal view; *b*, edge view; *c*, ventral view. (p. 731)

12—*Planulina ariminensis* d'Orbigny. ×68. *a*, Side view; *b*, edge view. (p. 731)

13—*Planulina wüllerstorfi* (Schwager). ×64. *a*, Side view; *b*, edge view. (p. 731)

14—*Cibicides concentricus* (Cushman). ×32. *a*, Involute view; *b*, edge view; *c*, evolute view. (p. 731)

15—*Cibidides io* Cushman. ×60. *a*, Evolute view; *b*, edge view; *c*, involute view. (p. 731)

16—*Dyocibicides biserialis* Cushman & Valentine. ×66. *a*, Involute view; *b*, evolute view. (p. 732)

17—*Planorbulina mediterranensis* d'Orbigny. ×36. *a*, Side view; *b*, side view. (p. 732)

Silvestri in 1896 for a form from the Pliocene of Italy. Judging from Cushman's figure, it would appear unlikely that an identical name was applied by coincidence to the same form but this possibility should be checked by a comparison of types. In any event, the Colombian form has been compared with Italian homeotypes of Silvestri's variety and found to be substantially different.

This species is abundant in Zone I and rare in Zone II.

Type locality.—Tropical Oil Company No. 34959.

Holotype.—AMNH, Cat. No. FT-1113.

Cassidulina vestae Redmond, n. sp.
Plate 77, figures 7a, b

Test very small, subglobular, slightly higher than broad, periphery very slightly lobulate; chambers distinct, slightly inflated, four pairs in the last-formed whorl; sutures distinct, limbate, slightly depressed; wall smooth; aperture a narrow arched opening at the base of the last chamber, nearly in the plane of coiling and partially filled with a thin, plate-like tooth extending from one side of the opening. Dimensions: length, 0.28 mm.; width, 0.22 mm.

This form is intermediate between *Cassidulina californica* Cushman and Hughes and *Cassidulina subglobosa* Brady var. *quadrata* Cushman and Hughes. It has the same number of chambers as *C. californica*, but the proportion of height to width is less. Though rare specimens have a quadrate profile when viewed from the apertural side, none of them are as equidimensional as *C. subglobosa* var. *quadrata* and the number of chambers is smaller. The apertural characteristics are closer to those of *C. californica*, the opening reaching to the base of the apertural face. In this respect, the Colombian form is very close to one figured by Renz (1948, p. 124, pl. 9, figs. 7a, b) from Venezuela as *Cassidulina* aff. *californica*, although the proportions of the Venezuelan form are different.

It is very rare in both zones.

Type locality.—Tropical Oil Company No. 34974.

Holotype.—AMNH, Cat. No. FT-1114.

Family Globigerinidae
Genus Globigerina d'Orbigny, 1826
Globigerina altispira Cushman and Jarvis
Plate 77, figures 8a–c

Globigerina altispira Cushman & Jarvis, 1936, Cushman Lab. Foram. Research Contr., vol. 12, p. 5, pl. 1, figs. 13, 14; Cushman & Todd, 1945, Cushman Lab. Foram. Research Special Pub. 15, p. 66, pl. 11, figs. 11, 12; Bermudez, 1949, idem, Special Pub. 25, p. 277, pl. 21, fig. 43.

This species is found only in Zone II where it is extremely rare.

Dimensions of figured specimen.—Diameter, 0.43 mm.; height, 0.40 mm.

Plesiotype.—AMNH.

Globigerinoides ruber (d'Orbigny)
Plate 77, figures 9a, b

Globigerina rubra d'Orbigny, 1839, in Ramon de la Sagra, Histoire physique, politique et naturelle de l'Île de Cuba; Foraminifères, p. 82, pl. 4, figs. 12–14.

Globigerinoides rubra (d'Orbigny). Stainforth, 1948, Jour. Paleontology, vol. 22, p. 122, pl. 26, figs. 11, 12; Bermudez, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 281, pl. 21, fig. 52.

Immature forms representing this species are common in both zones of the Tubara. Many individuals resemble the *Globigerinoides* sp. indet. figured and discussed by Stainforth (op. cit., p. 123), but have supplementary apertures more of the type of *G. ruber*.

Dimensions of figured specimen.—Maximum diameter, 0.33 mm.; height, 0.25 mm.

Plesiotype.—AMNH.

Globigerinoides tricamerata (Tolmachoff)
Plate 77, figures 10a, b

Globigerina tricamerata Tolmachoff, 1934, Carnegie Mus. Ann., vol. 23, p. 324, pl. 41, fig. 21.

Zones I and II contain a moderately rare form which closely approximates Tolmachoff's figure and description of *Globigerina tricamerata* both as to shape and as to coarseness of cancellation. While Tolmachoff doubted the existence of supplementary apertures in his Atrato species, the Tubara form has such obscure ones that they could easily be overlooked. Many specimens show no more than the top seg-

ment of the arch of somewhat smoother shell material which normally surrounds the actual opening in this and other species of *Globigerinoides*.

Dimensions of figured specimen.—Greatest diameter, 0.44 mm.

Plesiotype.—AMNH.

Genus ORBULINA d'Orbigny, 1839

ORBULINA UNIVERSA d'Orbigny

Orbulina universa D'ORBIGNY, 1839, in Ramon de la Sagra, Histoire physique, politique et naturelle de l'Île de Cuba; Foraminifères, p. 3, pl. 1, fig. 1; RENZ, 1948, Geol. Soc. America, Mem. 32, p. 149; BERMUDEZ, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 282, pl. 22, fig. 3.

A few representatives of this form were found in Zone II.

Family GLOBOROTALIIDAE

Genus GLOBOROTALIA Cushman, 1927

GLOBOROTALIA MENARDII (d'Orbigny)

Plate 77, figures 11a–c

Rotalia menardii D'ORBIGNY, 1826, Ann. Sci. Nat., sér. 1, tome 7, p. 273; Modèles, no. 10.

Globorotalia menardii (d'Orbigny). CUSHMAN, 1927, Bull. Scripps Inst. Oceanography, Tech. Ser., vol. 1, no. 10, p. 175; STAINFORTH, 1948, Jour. Paleontology, vol. 22, p. 124, pl. 26, figs. 36, 37; BERMUDEZ, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 286, pl. 22, figs. 9–11.

This species is rare in both zones of the Tubara.

Dimensions of figured specimen.—Diameter, 0.36 mm.; thickness, 0.17 mm.

Plesiotype.—AMNH.

Family ANOMALINIDAE

Genus PLANULINA d'Orbigny, 1826

PLANULINA ARIMINENSIS d'Orbigny

Plate 77, figures 12a, b

Planulina ariminensis D'ORBIGNY, 1826, Ann. Sci. Nat., sér. 1, tome 7, p. 280, pl. 14, figs. 1–3; Modèles, no. 49; CUSHMAN, 1929, Cushman Lab. Foram. Research Contr., vol. 5, p. 102, pl. 15, figs. 3, 4; CORYELL & RIVERO, 1940, Jour. Paleontology, vol. 14, p. 337, pl. 44, figs. 7a–c.

Both zones contain common and typical examples of this species.

Dimensions of figured specimen.—Diameter, 0.33 mm.; thickness, 0.08 mm.

Plesiotype.—AMNH.

PLANULINA WÜLLERSTORFI (Schwager)

Plate 77, figures 13a, b

Anomalina wüllerstorfi SCHWAGER, 1866, Novara-Exped., Geol. Theil, Bd. 2, p. 258, pl. 7, figs. 105, 107.

Planulina wuellerstorfi (Schwager). CUSHMAN, 1929, Cushman Lab. Foram. Research Contr., vol. 5, p. 104, pl. 15, figs. 1, 2; CORYELL & RIVERO, 1940, Jour. Paleontology, vol. 14, p. 337, pl. 44, figs. 3a–c; BERMUDEZ, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 293, pl. 23, figs. 37–39.

This species is extremely rare in both Tubara zones. As developed here, it is rather more evolute on the ventral side than the individuals figured in the above references.

Dimensions of figured specimen.—Diameter, 0.37 mm.; thickness, 0.09 mm.

Plesiotype.—AMNH.

Genus CIBICIDES Montfort, 1808

CIBICIDES CONCENTRICUS (Cushman)

Plate 77, figures 14a–c

Truncatulina concentrica CUSHMAN, 1918, U. S. Geol. Survey, Bull. 676, p. 64, pl. 21, figs. 3a–c.

Cibicides concentricus (Cushman). CUSHMAN, 1930, Florida Geol. Survey, Bull. 4, p. 61, pl. 12, figs. 4a–c; 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 120, pl. 21, figs. 4, 5; pl. 22, figs. 1, 2; CORYELL & RIVERO, 1940, Jour. Paleontology, vol. 14, p. 334, pl. 44, figs. 9a–c; BERMUDEZ, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 296, pl. 26, figs. 7–12.

This species is abundant in both zones. The Tubara forms are very close to Cushman's 1918 figure and to the individual figured by Coryell and Rivero from Haiti.

Dimensions of figured specimen.—Diameter, 0.57 mm.; height, 0.20 mm.

Plesiotype.—AMNH.

CIBICIDES IO Cushman

Plate 77, figures 15a–c

Cibicides pseudoungeriana (Cushman) var. *io* CUSHMAN, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 125, pl. 23, figs. 1, 2.

Cibicides io Cushman. CORYELL & RIVERO, 1940, Jour. Paleontology, vol. 14, p. 334, pl. 44, figs. 11a–c; BERMUDEZ, 1949, Cushman Lab. Foram. Research Special Pub. 25, p. 301, pl. 24, figs. 22–24.

This species is sporadically abundant in Zone I and generally abundant in Zone II.

Dimensions of figured specimen.—Diameter, 0.32 mm.; height, 0.15 mm.

Plesiotype.—AMNH.

Genus DYOCIBICIDES Cushman & Valentine, 1930

DYOCIBICIDES BISERIALIS Cushman & Valentine

Plate 77, figures 16a, b

Dyocibicides biserialis CUSHMAN & VALENTINE, 1930, Contr. Dept. Geol. Stanford University, vol. 1, no. 1, p. 31, pl. 10, figs. 1, 2a, b; CUSHMAN & TODD, 1945, Cushman Lab. Foram. Research Special Pub. 15, p. 72, pl. 12, fig. 10; BERMUDEZ, 1949, idem, Special Pub. 25, p. 310.

Most of the Tubara specimens show only the conical initial stage of this form. It is common in both zones.

Dimensions of figured specimen.—Length, 0.48 mm.; diameter of coiled portion, 0.30 mm.; thickness of coiled portion, 0.13 mm.

Plesiotype.—AMNH.

Genus PLANORBULINA d'Orbigny, 1826

PLANORBULINA MEDITERRANENSIS d'Orbigny

Plate 77, figures 17a, b

Planorbulina mediterranensis D'ORBIGNY, 1826, Ann. Sci. Nat., sér. 1, tome 7, p. 280, pl. 14, figs. 4–6; Modèles, no. 79; CUSHMAN, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 129, pl. 24, figs. 5–8; PALMER, 1945, Bull. Amer. Paleontology, vol. 29, no. 115, p. 76.

Both of the Tubara zones contain common representatives of this species, most of which are close to Cushman's figures.

Dimensions of figured specimen.—Diameter, 0.58 mm.; thickness, 0.18 mm.

Plesiotype.—AMNH.

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REVISION OF CROIXAN DIKELOCEPHALIDS—A COMMENT

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IN A recent paper, entitled "Revision of Croixan Dikelocephalids," G. O. Raasch (1951) has performed a distinct service to Cambrian paleontologists and stratigraphers. He has cleared up many of the inconsistencies and incorrect interpretations of the earlier work on the Dikelocephalinae by Ulrich and Resser (1930, 1933). While Raasch's paleontologic interpretations are undoubtedly correct, the stratigraphic terminology employed by him deserves further comment.

The difficulty stems from a belief apparently held by Raasch that the strata containing the dikelocephalid trilobites are not amenable to ordinary lithic differentiation. As a result, his member divisions of the Franconia and Trempealeau formations are based on faunal criteria. Unfortunately, Raasch nowhere clearly states that he is using a member definition different from that employed by the great majority of stratigraphers, and which has been accepted since the Ashley et al. (1933) report. To compound the confusion, Raasch retains such terms as St. Lawrence, Lodi, and Jordan, originally defined on lithologic criteria, for his members.

This discussion is confined to the strata above the Franconia formation, which are commonly referred to a single formation, the Trempealeau, or to the St. Lawrence and Jordan formations. Raasch holds the former view and divides the Trempealeau into four members. These are coincident with one or more of the various zonal units recognized by Raasch within the major portion of the *Saukia* zone. These units are numbered 1 through 13 in ascending stratigraphic order, as follows:

Trempealeau formation
- Jordan member (zonal units 7–13)
- Lodi member (zonal units 4–6)
- St. Lawrence member (zonal unit 3)
- Arcadia member (zonal unit 2)

The first zonal unit of the *Saukia* zone falls within the upper part of the underlying Franconia formation.

The following represents the *lithologic* units within the Trempealeau division:

- Jordan (basal part called Norwalk) sandstone
- Lodi siltstone, dolomitic siltstone, silty and sandy dolomite, shale, and very fine-grained sandstone
- St. Lawrence dolomite (discontinuous)

It can be shown that Raasch's Arcadia member embraces, in one section at Osceola, Wisconsin, both Lodi and Norwalk lithologies and that his Jordan member does likewise in other localities. As a result of a stratigraphic terminology, presently unaccepted and unfortunately not clearly explained, several confusing statements appear in the paper under discussion.

On page 138, Raasch says " . . . Lodi siltstone lithology occurs at eight different time-stratigraphic horizons and Norwalk sandstone lithology at six different horizons. Not only does the same lithology occur at a number of different stratigraphic horizons, but the same stratigraphic horizon is commonly represented by different lithologies in different areas." This might be interpreted to mean that in a single section mixtures of Lodi and Norwalk lithologies occur. Detailed field examinations in western Wisconsin and eastern Minnesota and examination of the published sections of Twenhofel, Raasch, and Thwaites (1935) indicate that, except for very minor intercalations at the boundary, Lodi siltstone and shale is everywhere succeeded vertically by Norwalk (basal Jordan) sandstone. The boundary between the two lithologies, however, does lie at different bio-stratigraphic horizons in different areas.

Raasch also states (p. 138) "*Dikelocephalus norwalkensis*, *Saukiella norwalkensis*, and *Tellerina norwalkensis* do not occur in the Norwalk nor does *Osceolia lodensis* occur in the Lodi." While these species do not occur

in the so-named units of Raasch, they *do* occur in Norwalk *sandstone* and Lodi *siltstone* respectively.

On page 140, Raasch states in referring to errors of Ulrich and Resser (1933), "The degree of stratigraphic error might best be summed up by citing the fact that, of the 473 figures used to illustrate the Saukinae, at least 290 are referred to the wrong stratigraphic horizon." While it is probably true that Ulrich and Resser believed their member units were of the same age over the whole region and they therefore assigned the 290 figured specimens to incorrect *bio-stratigraphic* horizons later recognized, it is unjust to summarily state they were assigned to incorrect stratigraphic horizons. When Ulrich and Resser reported an occurrence in Lodi shale or siltstone they without doubt meant shale or siltstone and when in Norwalk sandstone they meant sandstone.

In referring to specimens of *Saukiella pepinensis*, Raasch (pp. 144–145) states that the occurrence at Red Wing, Minnesota "is not from the Lodi shale, as the authors state, but from the *Saukiella pepinensis* zonal unit of the overlying Jordan member of the Trempealeau formation." It is here maintained, after close examination of the exposed section at Red Wing, that this occurrence is in the Lodi shale, and that the Lodi contains zonal units as high as *Saukiella pepinensis* (unit #10). In this Red Wing section, the Lodi lithology is overlain by the Jordan sandstone.

On page 146, in referring to *Tellerina leucosia* from Osceola, Raasch states "The occurrence is not the Norwalk sandstone . . . , but the basal Trempealeau, Arcadia member." This fauna does come from Norwalk *sandstone* as reported by Ulrich and Resser. It has been shown (Nelson, 1951, pp. 768–770) that at Osceola the fauna (including *Tellerina leucosia*) characteristic of the Arcadia member of Raasch occurs in siltstone and in overlying sandstone which comprise the Lodi and Norwalk (basal Jordan) respectively. Referring to the strata containing these forms as the Arcadia member, as Raasch does, is contrary to presently accepted stratigraphic procedure.

As an alternative to Raasch's member division of the Trempealeau, a return to the earlier established divisions based on lithologic criteria is deemed essential. To replace the inferred interpretation that Lodi and Norwalk lithologies occur intimately intermixed, the following is offered as more closely fitting the observed facts.

While it is recognized that the zonal units of Raasch are to a degree time-transgressive, they more closely parallel lines of synchrony than do the lithic units.

It appears that following accumulation of silts and shales, etc. of the Lodi, sand deposition representing the Norwalk (basal Jordan) sandstone began earliest in the northwest part of the depositional region. It is there, as at Osceola, where faunal unit #2 (Raasch's Arcadia member) occurs below and above the siltstone (Lodi)-sandstone (Norwalk) boundary. To the southeast toward Madison, Wisconsin, in a direction roughly normal to the shoreline, the base of the sand succession rises stratigraphically, until, as at Lodi, Prairie du Sac, and Spring Green, Wisconsin, the Lodi-Norwalk boundary lies some distance above Raasch's zonal unit #6. At Red Wing and Winona, Minnesota, however, siltstone deposition apparently persisted for longer periods. There, the siltstone-sandstone boundary lies above zonal unit #11.

Much further stratigraphic work remains to be done on the problem of the Trempealeauan rocks in the type area, but the facts at hand appear to support the above interpretation. It can at least be regarded as a working hypothesis in guiding further investigation.

This note is not the place to discuss the problem of terminology involving the terms St. Lawrence, Lodi, Norwalk, Jordan, and Trempealeau. That will be discussed in a subsequent paper. It seems clear and essential, however, that regardless of usage of these stratal terms as members or formations, they must be employed in a strict lithic sense and in none other.

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ARCHIMEDES AND ITS GENOTYPE[1]

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ABSTRACT—Hitherto overlooked publications, mainly by James Hall and D. D. Owen, affect the nomenclature of *Archimedes*, as well as of other fossils not discussed in this paper. *Archimedes* Owen, 1838 [genotype: *A. wortheni* Hall, 1856?] is a senior objective synonym of *Archimides* [*sic*] Owen, 1838 [genotype herein designated: *A. wortheni* Hall, 1856?], and a senior subjective synonym of *Archimedipora* d'Orbigny, 1849 [genotype: *A. archimedes* d'Orbigny, 1849].

INTRODUCTION

CONSIDERABLE discussion has transpired as to what generic name should be used for organisms commonly referred to as *Archimedes*. Except in several publications discussed in this paper, a few early manuals of paleontology, and descriptive studies published by Toula and by Stuckenberg in 1875, all workers used "*Archimedes*" between 1838 and 1943, when Easton (1943, pp. 142, 143) concluded that the evidence required "*Archimedes*" to be replaced by "*Archimedipora*." Easton indicated the undesirability of this procedure, but he felt constrained to use *Archimedipora* until action by the International Commission on Zoological Nomenclature would relieve him of the obligation. Subsequently the subject was considered by Condra and Elias (1944, pp. 13–16), again by Easton (1944, pp. 406, 407), and then by Crockford (1947, pp. 16, 17). These students agree on some points and disagree on others in various combinations. Elaboration of the nuances of their contentions is unnecessary here, for most interested paleontologists known to us desire that *Archimedes* be recognized as the valid name of the genus under consideration and that *A. wortheni* be fixed as the genotype.

As several paleontologists believe that the name *Archimedes* should be stabilized by the International Commission on Zoological Nomenclature, we set out to prepare a petition. After finding evidence hitherto overlooked, we have arrived at a solution that no longer requires any action by the International Commission. The circumstances, as we interpret them, follow.

NOMENCLATURAL HISTORY

Original reference.—The name *Archimedes* first appeared (Owen, 1838a, p. 13) in the following sentence:

> In the bed of Oil Creek, then, on the road from Troy to Fredonia, the coal sandstone may be found resting on a reddish stratum of a somewhat arenaceous limestone—the uppermost member of this sub-carboniferous group, and characterized by a fossil, described by Lesueur under the name of *Archimedes*, on account of its screw-like form.* (See Plate I, fig. 2.)

The pertinent part of the footnote reads: " . . . whenever one finds in that State [Tennessee], limestone having an oolitic structure . . . and containing fossil Archimedes or Pentremites. . . . "

Foregoing texts or other allusions to *Archimedes* have appeared in a series of similarly titled reports that are remarkable for the confusing bibliographic problems raised. Dates of 1838, 1839, 1859, and combinations of two dates are to be found on reports bound in with subsequent reports, or printed by more than one publishing house in the same year but having slightly different make-up (Owen, 1838a, 1838b, 1839a, 1839b, 1839c, 1859a, 1859b, and 1859c). Careful examination of these references furnished the data for the present interpretation of the status of *Archimedes* and of its genotype. We agree with the U. S.

[1] Publication authorized by the Director, U. S. Geological Survey.

Geological Survey Library catalog that the first edition of Owen's first report (Owen, 1838a) was printed by Bolton & Livingston in 1838. A copy of this edition bearing corrections in D. D. Owen's handwriting is before us. He let the usual spelling "*Archimedes*" stand in this annotated copy.

Second reference.—An edition of the same text printed by J. W. Osborn and J. S. Willets (Owen, 1838b) and dated 1838 contains the same allusion to the genus, but the name is spelled "Archimides" in both the text and the footnote. We consider this to be the second edition of this report. The variant spelling "*Archimides*" was apparently deliberate. We here designate *Fenestella* (*Archimedes*) *wortheni* Hall, 1856? (p. 2) [=Hall, 1857c, p. 178] the type species of *Archimides* Owen, 1838 (p. 13). This action renders *Archimides* a junior objective synonym of *Archimedes*.

The plate of figures to which reference was made was not published in either of the first two editions, or in any subsequent editions of this report. We have observed various spellings of the generic name in different editions. These are noted in the list of references.

The immediate problem is whether Owen's account quoted above constitutes a generic description of *Archimedes*. The key is the compound word "screw-like," for nothing else in the statement is morphologically descriptive. The establishment of a locality and of an age does not validate a genus, and no species was mentioned. Although the description is essentially reduced to one word, this brevity does not invalidate the genus provided that the one word renders the genus recognizable (and might not invalidate it in any case). If it had been called "large," or "flat," one might argue about its distinctiveness, but calling it "screw-like" seemingly eliminates everything but gastropod columellas and what paleontologists commonly call *Archimedes*. We consider that this constitutes description of the genus *Archimedes* and that the name is available from 1838. After 1838 all that was required in order to stabilize the genus was to have some species referred to it.

Even if one maintained that this is too wide a choice to make (gastropods versus Bryozoa), the problem is narrowed down in Owen's so-called Second Report published in 1839. Therein he (Owen 1839a, pp. 10, 38, 43) mentioned *Archimedes* (variously spelled) and assigned it to the "Polypiferae (fossil corallines)" (p. 38). This action, in addition to the 1838 report, leaves no doubt in our minds as to what *Archimedes* is supposed to be because the word "corallines" of a former time included the bryozoans of present usage.

Cases of this sort are covered by Opinion 46 of the International Commission on Zoological Nomenclature, which instructs us to reason that *Archimedes*, being without species when originally proposed, contained all *screw-like* fossils in 1838, all *screw-like corallines* in 1839, and was not really stabilized until the first species were referred to it.

Prior to our present report, we know of no suggestion that *Archimedes* should date from 1838. Indeed, the first reference to Owen's use of *Archimedes* in 1838 seems to be by Condra and Elias (1944, p. 13), but they only say Owen "used the name *Archimedes* limestone." Actually the combination of words "*Archimedes* limestone" does not appear in the 1838 and 1839 editions, although the inference is there. Inasmuch as Owen's surveys are well known, the reference to *Archimedes* must have been deliberately omitted from generic synonymies because of the casualness of the description because of the lack of guidance before Opinion 46 was promulgated, or because of confusion over the various similarly titled articles in which some of the usages definitely constituted only *nomina nuda*.

Third reference.—In 1842 Owen (1842, p. 19) described the organism as " . . . a very remarkable fossil coralline, resembling the *Retepora* of *Lin.*, but verticillated spirally like a continuous screw; described by *Lesueur* under the appropriate name of Archimedes.*" The footnote reads, "I am not sure that Lesueur ever published his description of this fossil; . . . he considered it, I believe, a new genus; but it may be only a new species of *Retepora;* if so, most aptly entitled *Retepora Archimedes*." An accompanying sketch was entitled "Archimedes, of Lesueur." Lesueur did not publish on the subject.

Easton once argued (1943, p. 142) that the above paragraph would not constitute generic description, but he (Easton) now

accedes to Crockford's reiteration (1947, p. 17) of the long-established opinion that it should be considered as a generic description. The only flaw in its use is that it is not the earliest description; the 1838 reference was not mentioned (and may not have been read) by either Easton or Crockford. Nickles and Bassler (1900, p. 167) and Bassler (1935, p. 49) cited *Archimedes* as being proposed in Owen's publication in 1842.

As of 1842, no species had been definitely referred to *Archimedes*, for it is clear that Owen's concept of the genus coincided exactly with his concept of the provisional species *Retepora archimedes*. Subsequent work has not established the specific identity of the figured specimen, so the name *Retepora archimedes* refers only to a *species dubia*. In any event, this provisional species was not directly assigned to the genus *Archimedes* by Owen or by any other author prior to 1856? (Hall, 1856?) when the first recognizable species of the genus were described.

Fourth reference.—Yandell and Shumard (1847, p. 25) used "*Archimides*" [*sic*] in a generic sense in a faunal list, but they did not give any evidence to indicate what organism they referred to.

Fifth reference.—D'Orbigny first published and described the genus *Archimedipora* in 1849 (p. 502), at which time he cited as the only species "*A. archimedes*," which he indicated was the same as the *Retepora archimedes* considered by Owen in 1842. In effect, this publication validates the name *Retepora archimedes*; but, as pointed out in the preceding discussion, the species is not recognizable. The name *Archimedipora* is a junior subjective synonym of *Archimedes* Owen, 1838.

Sixth reference.—In 1850 (p. 102) d'Orbigny again published a description of *Archimedipora*, and as the only species under it he indicated "*Archimedes*, d'Orb. *Retepora Archimedes*, Lesueur, 1842."

Seventh reference.—The next year, d'Orbigny (1851, p. 104) published a diagnosis of *Archimedipora* but cited no species.

Eighth reference.—In 1852 Owen (pl. 4, figs. 1, 1a, and explanation) figured another specimen as "*Retepora Archimedes*." He said it had been known for many years "under the name of *Archimedes*." Regarding the fossil figured in 1842 he said, "it seemed to be a species of *Retepora* coiled in the shape of a screw."

Ninth reference.—In 1853 G. G. Shumard (p. 180) cited "*Archimedipora archimedes*" in a faunal list. In another paper in the same volume, B. F. Shumard (1853, p. 202, pl. 1, fig. 6) discussed and figured "*Archimedipora archimedes*."

Tenth reference.—Two more editions of the Marcy report were published in 1854. "*Archimedipora archimides*" [*sic*] was cited in the paper by G. G. Shumard (1854, p. 157), and "*Archimedipora archimedes*" was discussed and illustrated by B. F. Shumard (1854, p. 175, pl. 1, fig. 6). The volume published as a Senate Document contains identical references, but the pages differ.

Eleventh reference.—Hall in 1856? (pp. 2–4) and 1857 (1857c, pp. 176–179) described five new species of *Archimedes*, the first two of which he listed as "Fenestella (*Archimedes*) Owenana and Fenestella (*Archimedes*) Wortheni." According to the title of his paper, he considered *Archimedes* to be a genus, but he used the word in the text in a subgeneric sense. He thought that *Fenestella* and *Archimedes* were separable only on mode of growth and wrote (Hall, 1856?, p. 1, and 1857c, p. 177), "should this character be hereafter considered of sufficient importance, I propose to retain Le Sueur's original name 'Archimedes'." Although it is of interest to find that this paper was probably issued in 1856, the date is of no particular consequence as no question of priority is involved.

Condra and Elias (1944, pp. 14, 15) attribute the genus to Hall's description of 1857, ignoring the description sufficient to validate the genus in Owen's paper of 1838.

The five species named by Hall in 1856? are the first species directly assigned to *Archimedes*. Under case 5 of Opinion 46 of the International Commission on Zoological Nomenclature, the genotype must be selected from one of these species.

Twelfth reference.—In 1889 S. A. Miller (p. 292) designated *Archimedes wortheni* as genotype of *Archimedes*.

CONCLUSIONS

1. *Archimedes* was proposed without species by Owen in 1838.

2. The variant spelling *Archimides* published by Owen in 1838 is a junior objective

synonym of *Archimedes* Owen, 1838. The type species of *Archimides* is herein designated *Fenestella* (*Archimedes*) *wortheni* Hall, 1856?.

3. *Archimedipora* was proposed by d'Orbigny as a monotypic genus in 1849. The type species is of doubtful specific identity. *Archimedipora* is a junior subjective synonym of *Archimedes*.

4. Hall referred the first group of species to *Archimedes* in 1856?.

5. The genotype of *Archimedes* is *Fenestella* (*Archimedes*) *wortheni* Hall, 1856?, and was designated as such by Miller in 1889.

6. The following synonymy of the genus *Archimedes* covers the period 1838 through 1857, the interval during which data bearing on the recognition of the genus were published. Three of these articles along with some subsequent references are listed by Nickles and Bassler (1900, p. 167). Authors and dates cited in this abbreviated synonymy refer to the bibliography published herewith.

ARCHIMEDES Owen, 1838. Genotype: *Fenestella* (*Archimedes*) *wortheni* Hall, 1856?
Archimedes Owen 1838a, p. 13. (Proposed without species.)
Archimides Owen 1838b, p. 13. (Variant spelling; an available synonym.)
Archimedes. Owen 1839a, p. 33. (Referred to Polypiferae.)
Archimides. Owen 1839b, p. 38. (Referred to Polypiferae.)
Archimides. Owen 1839c, First rept., p. 13; Second rept., p. 38.
Archimedes. Owen 1842, p. 19. (Provisionally proposed *Retepora archimedes*.)
Archimides. Yandell and Shumard 1847, p. 25.
Archimedipora d'Orbigny 1849, p. 502. (Genotype: *A. archimedes* = *Retepora archimedes* Owen, 1842, both being specifically unrecognizable.)
Archimedipora. d'Orbigny 1850, p. 102.
Archimedipora. d'Orbigny 1851, p. 104.
Archimedes. Owen 1852, expl. to pl. 4, figs. 1, 1a. (Figured "*Retepora Archimedes*.")
Archimedipora. G. G. Shumard 1853, p. 180.
Archimedipora. B. F. Shumard 1853, p. 202.
Archimedipora. G. G. Shumard 1854, p. 157.
Archimedipora. B. F. Shumard 1854, p. 175.
Archimedes. Hall 1856?, pp. 1–3. (Described "Fenestella (*Archimedes*) Wortheni" along with other species.)
Archimedes. Hall 1857a, p. 53.
Archimedes. Hall 1857b, p. 5.
Archimedes. Hall 1857c, pp. 176–178. (See Hall 1856?.)
Archimedes. Hall 1857d, p. 190.
Archimedes. Hall 1857e, p. 4.
Archimedes. Hall 1857f, pp. 203–204.
Archimedes. Hall 1857g, pp. 17–18.
Archimedes. Hall 1857h, p. 2.

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Note: The exact order of publication for the following Hall references of 1857 is uncertain. The articles were published as individual brochures as well as in journals, and the separates may have been printed and distributed in advance. The chronology is immaterial as it does not affect the status of *Archimedes* or its type species.

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——, 1839b, Second report of a geological survey of the State of Indiana, made in the year 1838 . . . 54 pp., Indianapolis, Osborn and Willets. [This presumably is the 2d edition of this report. *Archimides* [*sic*] is referred to the Polypiferae on page 38, archimedes [*sic*] is used on page 10, and *Archimedes* is mentioned on page 43.]

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MANUSCRIPT RECEIVED MAY 27, 1953

JOURNAL OF PALEONTOLOGY, VOL. 27, NO. 5, PP. 742–752, 3 FIGS., SEPTEMBER 1953

PALEONTOLOGICAL NOTES

POSSIBLE PLANKTONIC OCCURRENCE OF *GLOBIGERINA PACHYDERMA* (EHRENBERG)

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Globigerina pachyderma (Ehrenberg), while commonly accepted as being a pelagic species, has rarely been identified in plankton tows or seawater samples. Cushman and Henbest (1940) and Brady (1884) have remarked that this species has never been established as truly planktonic, but Sir John Murray (1897) listed the species as one of those identified in plankton tows taken by the CHALLENGER expedition and Phleger (1945, p. 382) identified specimens captured by a plankton tow taken at a depth of 975 meters at 40°43′N., 69°50′W. in the northwest Atlantic. Specimens of this species have been identified by the author in cores of sea-ice taken in the Bering Sea in the winter of 1951, under circumstances which suggest that they were present in the surface layers of the water when they were frozen.

Two core samples of sea-ice were taken at 64°44′N., 169°36′W. during the winter of 1951, and were each cut into sections 4 to 6 inches long. These sections were bottled and were studied by the author almost a year after they had been collected. Because no preservative had been added to the samples, much of the organic matter had decomposed when the samples were studied.

It was found that each section contained a large amount of fine detritus. Aliquot portions of each sample were slowly dried, weighed and treated with chromic acid. It was found that 90% of the particulate material was oxidized by this process, and thus it has been concluded that it was organic in nature.

Another dried aliquot portion from each sample was studied under a binocular microscope. These samples contained diatom frustules (mostly of the genus *Coscinodiscus*), decomposed zooplankton, tests of *Globigerina pachyderma*, a few flakes of mica, a few small grains of quartz, and a large fraction of unidentifiable material which the first test suggests was organic. The tests of *G. pachyderma* (Fig. 1) were found in the lowermost 6 inches of the first core, which was 39 inches long, and in the top and bottom 6 inches of the second core, which was 18 inches long. These were found associated with a few flakes of mica.

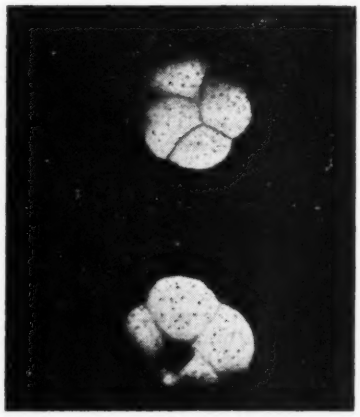

FIG. 1—Specimen (×64) of *Globigerina pachyderma* (Ehrenberg) taken in sea-ice in the Bering Sea at 64°44′N., 169°36′W. in the winter of 1951.

It is considered that this ice is sea-ice which had never been grounded. Mica could be present in turbid water which is common in the Bering Sea just before freezing begins (Buffington, Carsola and Dietz, 1949). The fact that the layers containing specimens of *G. pachyderma* contain little inorganic material suggests that they were frozen in the ice near the surface and were not incorporated by grounded ice. The lack of

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benthonic Foraminifera supports this contention.

Gran (1904) and Nansen (1906) have referred to many cases where the undersides of ice-floes in the North Polar Sea were colored brown or reddish-brown by large populations of planktonic diatoms and other organisms. It has been suggested that these organisms were frozen while near the surface of the sea. When the sea is covered with ice the euphotic zone becomes thinner and shallower because the passage of radiant energy through the surface ice is impeded. As a result, phytoplankton concentrate just below the underside of the ice to be as close to the source of energy as possible. It is logical to expect that zooplankton will also tend to concentrate near the ultimate source of their food supply. Because sea-ice grows in thickness by accretion to the underside of ice-floes (Malmgren, 1927; H. O. 77, 1951, p. 31) conditions are favorable for the incorporation of this biocoenose. It is considered that the specimens of *G. pachyderma* referred to in this paper were trapped in the ice in this manner, and if this be the case, it follows that the existence of this species in the plankton is reaffirmed.

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JURASSIC PLESIOSAUR VERTEBRAE FROM CALIFORNIA

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ABSTRACT—*Plesiosaurus hesternus* n. sp. is based on two vertebrae from San Luis Obispo County, believed to be derived from a limestone concretion in Franciscan shales.

The only vertebrates recorded from the Franciscan-Knoxville of California are *Ichthyosaurus californicus* Camp, 1942, and *I. franciscanus* Camp, 1942, each represented by a section of the rostrum in a chert boulder. Both were found in Quaternary gravels on the west side of the San Joaquin Valley, probably washed down from the high Franciscan outcrops to the west.

In 1949 Miss Betty Olsonowski, on a field trip conducted by Prof. J. W. Durham, found two plesiosaur vertebrae in a limestone boulder that Dr. Durham believes weathered out of a limestone lens in the Franciscan shales. This adds a third vertebrate to the Franciscan fauna, and is the first Jurassic plesiosaur west of the Rocky Mountains. Since this is a new record, the specimen is named and described even though it cannot be demonstrated to differ from all previously known species.

PLESIOSAURUS HESTERNUS Welles, n. sp.

Type.—A posterior dorsal and a sacral vertebral centrum. University of California Museum of Paleontology, no. 41599.

Locality.—Limestone concretion found as float in saddle at head of NW.-SE. trending valley about 1 mile SW. of Stanley Mt., NE. ¼ of NE. ¼ Sec. 5, T. 11 N., R. 32 W.,

San Bernardino B. and M. On Oakley Ranch, Nipomo, San Luis Obispo Co., Calif. U. C. loc. V4958.

Horizon.—Franciscan-Knoxville shales of Tithonian age as mapped by Taliaferro, 1943, fig. 7.

Diagnosis.—A large plesiosaur; neural arches separate from centra; pedicel facets diverging posteriorly at angles of 50° (post. dorsal) and 30° (sacral); floor of neural canal flat, raised 3 mm. above pedicel facets; ends of centra excavated 8 mm. anteriorly and posteriorly.

Description.—The sacral centrum is practically uncrushed, although its left side is weathered. It is depressed oval in section,

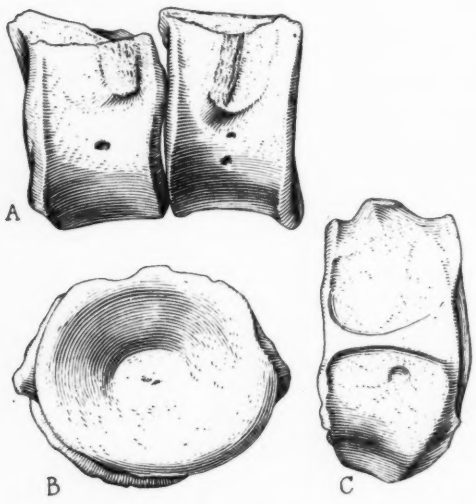

FIG. 1—*Plesiosaurus hesternus*, type. A, Left lateral view of posterior dorsal and sacral centra. B, Anterior view of sacral centrum, C, Dorsal view of same, anterior to left. Univ. Calif. Mus. Pal. no. 41599. ×½. Drawn by O. J. Poe.

with amphicoelous concavities about 8 mm. deep. The center of each concavity is not a smooth cone, but bears a flat rugose oval center 15 mm. high and 20 mm. broad. The ventral surface of the centrum is smoothly convex transversely and concave anteroposteriorly. The ventral nutrient foramina lie nearer to the rib facet than to the midline. The pedicel facets are open and outline between them an isosceles triangle with a two-centimeter base, its apex forward, occupying the posterior half of the centrum. The effect of the triangle is to separate the posterior half of the pedicel facets at an angle of 50°. A narrow (3 mm.) ridge runs anteriorly from the apex of the triangle to the anterodorsal border of the centrum. The triangle and ridge are elevated 4 mm. above the pedicel facet and together form a nearly flat floor for the neural canal, quite different from the smooth hemicylindrical trough usually found in plesiosaurs. The rib facet extends 27 mm. down the side of the centrum, faces posteriodorsally, and is 10 mm. from the anterior face, 6 mm. from the posterior. The rib facet is continuous with the pedicel facet at an angle of 110°. Indices are 37,154:176.

The dorsal centrum is less well preserved, but evidently differed only slightly from the sacral. It has a higher and shorter rib facet (18 mm. high) that is confined to the posterior half of the centrum, makes an angle of 120° with the pedicel facet, and faces 50° posteriorly. Indices are 37,154:178.

I have not been able to find detailed descriptions of comparable vertebrae so cannot estimate the taxonomic importance of the flat neural canal. The indices are elasmosaurian and are very close to those for *Plesiosaurus trochanterius* of the Kimmeridgian (57,144:174 for an ant. caudal) and next to *Cryptocleidus oxoniensis* of the Oxfordian (38,140:188) but do not prove closer relationship than to the superfamily Plesiosauroidea. The two families in this superfamily are the Plesiosauridae and Elasmosauridae. These are separated on characters of cervical vertebrae and limbs, evidence that is lacking here. However, the Plesiosauridae are in general smaller and earlier in occurrence, and the genus *Plesiosaurus* has included a multitude of forms. The reptile is therefore assigned to *Plesiosaurus* as a matter of convenience and with full realization that additional material may reveal other relationships.

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TAXONOMY OF THE TRILOBITE GENERA *LONCHOCEPHALUS* AND *WELLERASPIS*

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INTRODUCTION

It has recently been observed that two species set up by the writer, namely, *Lonchocephalus waddlei* and *Lonchocephalus swartzi* "are certainly congeneric if not conspecific with *Welleraspis jerseyensis* (Weller)" (Wilson, 1952: 279–281). Elsewhere, in the same paper (Plate 1 opposite page 282), the separation between the Warrior formation and the Stacy member of the overlying Gatesburg is drawn to coincide with the uppermost occurrence of *Welleraspis* in the Warrior. A subscript on this diagram states "genus *Welleraspis* same as *Lonchocephalus swartzi* Tasch." Obviously, it is of some importance to clarify the taxonomy of the respective trilobite genera and species involved.

It would seem desirable, when generic or specific assignments are in dispute, to demonstrate the superiority of the proposed assignment by a point by point citation and comparison of unit characters of the test. This would enable any other investigator to evaluate the basis upon which the proposed assignment rests. In the present instance, unannotated referral was made to previously published material, namely, Howell's figures and redescription of *Welleraspis jerseyensis* (1945:2; plate 1, figures 1–4).

SIMILARITIES AND DIFFERENCES OF THE DISPUTED GENERA AND SPECIES

Rubber casts of the type specimens of *Welleraspis jerseyensis* and types of *Lonchocephalus waddlei* and *Lonchocephalus swartzi* were measured under the binocular microscope using a micrometer eyepiece. Figure 1 indicates the series of measurements taken on all specimens. Table I gives the tabulation of measurements.

As indicated in Table I, measurement "A" shows that for the lonchocephalids, the base of the glabella is distinctly wider than for *Welleraspis*. Similarly, "B" shows a similar difference in length of glabella, lonchocephalid length being greater. The

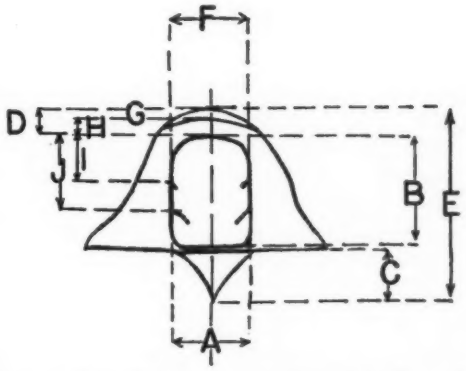

FIG. *1*—Schematic representation of *Welleraspis jerseyensis*, ×10. A—posterior width of glabella; B—length of glabella; C—length of occipital ring and spine; D—total width of anterior portion of cranidium; E—total length of cranidium including occipital spine; F—anterior width of glabella; G—maximum width of rim; H—maximum width of frontal limb; I—distance back from front of glabella of anterior glabellar furrow; J—distance back from front of glabella of posterior glabellar furrow.

over-all length from rim to spine tip is greater in the lonchocephalids. This cannot be attributed solely to the generally greater spine length (measurement "C") since for *L. swartzi* this figure is 1.2 mm. which is less than that for any specimen of *Welleraspis*. Frontal limb width (measurement "H") is of importance because while apparently invariable in the *Welleraspis* specimens, it varies from 0.1 to 0.5 mm. larger in the lonchocephalids. The posterior furrows in the lonchocephalids (measurement "J") are farther back from the front of the glabella than those of the *Welleraspis* types. Width of fixed cheeks (not shown in figure 1) is about the same in both genera (1.4 mm.–1.5 mm.). Measurement "F" shows that the anterior width of the glabella in the lonchocephalids measured is distinctly greater than in *Welleraspis* specimens.

A comparison of the anterior and posterior width of the glabella (measurement "A") indicates that for all lonchocephalids

TABLE I. COMPARATIVE MEASUREMENTS ON TYPE SPECIMENS OF THREE LONCHOCEPHALIDS AND TYPES OF *Welleraspis*, IN MM.

Measurement	*Lonchocephalus*			*Welleraspis jerseyensis*				
	L. waddlei 115613	*L. waddlei* 115612	*L. swartzi* 115611	A*	B	C	D	U†
A	3.3	3.8	3.3	2.7	2.0	2.6	2.6	2.1
B	4.0	4.3	3.6	3.1	2.7	3.0	3.0	2.8
C	2.0	2.5	1.2	1.7	1.6	1.3	1.9	1.5
D	1.2	2.0	1.5	0.9	—	0.9	1.0	—
E	7.0	8.9	6.5	5.6	—	5.5	5.6	—
F	3.2	3.5	3.0	2.5	2.2	2.5	2.5	2.2
G	0.4	1.1	0.4	0.4	—	0.4	0.3	—
H	0.6	0.9	1.0	0.5	—	0.5	0.5	—
I	1.4	1.9	1.5	1.5	1.0	1.3	?	1.1
J	2.8	2.9	2.4	2.0	1.6	2.0	2.1	2.0

* Rubber casts.
† Unlettered rubber cast.
A—posterior width of glabella.
B—length of glabella.
C—length of occipital ring and spine.
D—total width of anterior portion of cranidium.
E—total length of cranidium including occipital spine.
F—anterior width of glabella.
G—maximum width of rim.
H—maximum width of frontal limb.
I—distance back from front of glabella of anterior glabellar furrow.
J—distance back from front of glabella of posterior glabellar furrow.

there is a gentle taper anteriorly. For *Welleraspis* types "A," "C" and "D" this is also true; while for types "B" and "U" there is a gentle taper posteriorly.

One of the most outstanding morphologic distinctions between the types of *Welleraspis* and those of *Lonchocephalus* is the nature of the occipital ring and occipital spine. If Howell (op. cit.) had figured a lateral side view of *W. jerseyensis*, it would be immediately apparent, when compared to similar views of *L. waddlei* and *L. swartzi*, that the two genera are distinct. A schematic representation of the three species is given in figure 2.

All type specimens of *Welleraspis* have a distinctly triangular ring and spine which cannot be differentiated. It should be noted that all the specimens studied were exfoliated. *Lonchocephalus waddlei* has an "occipital ring joined anteriorly by narrow connectives issuing from its sides to inner side of dorsal furrow, posteriorly converges to form a thick based, tapering spine, slightly curved beyond root area" (Tasch, 1951:300). *Lonchocephalus swartzi* has an "occipital ring narrow, flat, extending into a slender upturned spine" (Tasch, idem). Thus, the nature of the occipital ring and spine in the lonchocephalids differs to such a degree from that in the *Welleraspis* types as to be a valuable diagnostic character.

Lonchocephalids, as defined by Kobayashi (1935:258), have an ocular ridge present. This holds for *L. waddlei* where the ridge though present is faint and with *L. swartzi* which has an ocular ridge "slightly raised, very narrow, extending across fixed cheeks diagonally" (Tasch, op. cit). The types of *Welleraspis* show no ocular ridge and none is referred to in Howell's redescription of the genus.

The brim (seen in lateral side view) in *L. swartzi* is short and steeply convex. In *L. waddlei*, it is convex and ring-like "around which a thicker, ring-like, more gently curved border appears" (idem). The brim in *Welleraspis jerseyensis* is concave.

Howell (op. cit.: 3) observed that the type of *Welleraspis jerseyensis* showed "near each anterior corner of the glabella . . . a very faint indication of a small pit, which is

so indistinct that it can hardly be seen." This, however, does not prevent the front of the glabella from being "very bluntly rounded in front." In contrast, *Lonchocephalus swartzi* shows a very distinct anterior indentation on either side of the first glabellar lobe, which does prevent the front of the glabella from being very bluntly rounded. Width of glabella below indentation is 3.0 mm.; width above indentation is 2.0 mm.

Lonchocephalus species and *Welleraspis* species may be expected to share several characteristics in common. These include: number of glabellar furrows, presence of occipital spine, convexity of glabella, relatively small fixed cheeks, etc. This is so since these are family characteristics and since both genera are assigned to the same family, Solenopleuridae Angelin (Kobayashi, op. cit.: 258; 263–264). However, the convexity of the brim (cf. the lonchocephalids described by Walcott, 1916:188–195), the type of occipital ring and slender spine, the presence of an ocular ridge, are, in themselves, sufficiently distinctive to separate *Lonchocephalus* species from *Welleraspis* species.

In light of the above data and discussion, it is concluded that:

(1) *Lonchocephalus swartzi* is not congeneric or conspecific with *Welleraspis jerseyensis*.
(2) *Lonchocephalus waddlei* is not congeneric or conspecific with *Welleraspis jerseyensis*.
(3) The similarities between *Lonchocephalus* and *Welleraspis* are familial and not generic. Each genus has distinctive characters that differentiate it from the other.

ACKNOWLEDGEMENTS

The writer is pleased to acknowledge the assistance of Professor B. F. Howell in obtaining rubber casts of the types of *Welleraspis jerseyensis* from the New Jersey Geological Survey. These were prepared by Mr. Henry Herpers of the Survey. Professor Howell also loaned several pertinent reference books. Professor Cecil H. Kindle kindly loaned some reference material. Dr. G. A. Cooper arranged for loan of the specimens of the lonchocephalids deposited at the Smithsonian Institution by the writer.

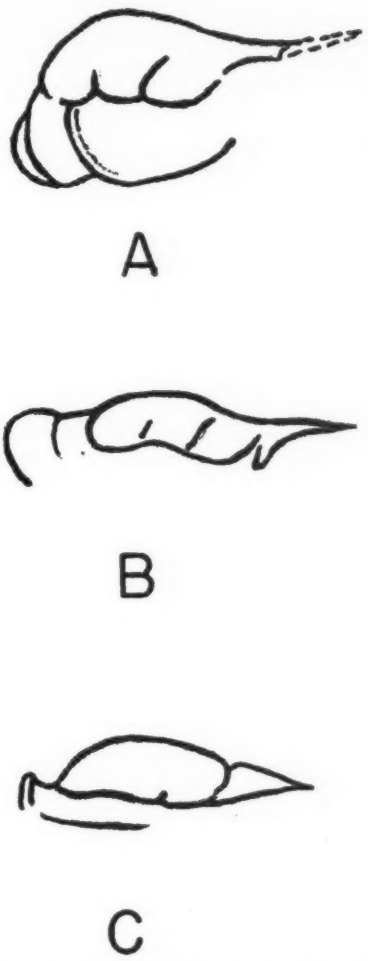

FIG. 2—Schematic representation showing lateral side view. A—*Lonchocephalus swartzi*, holotype, ×3½; B—*Lonchocephalus waddlei*, paratype, ×3; C—*Welleraspis jerseyensis*, rubber cast of type specimen A, ×3. Compare curvature of frontal limb and distinctive character of occipital ring and spine differentiating the lonchocephalids from the *Welleraspis* species. [A and B traced from photographs (Tasch, 1951, plate 45, figs. 17 and 2 respectively); C drawn from type specimen A viewed under a binocular microscope].

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PRIMITIVE *FUSULINELLA* FROM SOUTHERN MISSOURI: A CORRECTION

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Two photographs of the same specimen but at different magnifications were illustrated by figures 19 and 20 on Plate 41 of this volume. The latter one of these two illustrations and the following four illustrations were incorrectly labeled in the explanation of this plate. All illustrations on the plate were correctly listed in the text. The explanation of plate 41 should read as follows:

EXPLANATION OF PLATE 41

All illustrations on this plate are of unretouched photographs.

FIGS. *1–12*—*Fusulinella clarki*, n. sp. *1, 6*, Axial section of the holotype; *2, 3, 5, 7–10, 11*, axial sections of paratypes; *4, 12*, sagittal section of a paratype. *1–4* are ×40 and all others are ×20. Jasper County, Missouri (M-38). (p. 325)

13–20—*Profusulinella fittsi* (Thompson). *13–15, 18–20*, Axial sections of topotypes; *16, 17*, sagittal sections of topotypes. *13–17* and *20* are ×40 and all others are ×20. About 100 feet above the Wapanucka limestone. Center NW¼, sec. 10, T. 1 N., R. 8 E., Coal County, Oklahoma (O-126). (p. 323)

21—*Fusulinella fugax* Thompson. Axial section of a paratype, ×20. Fra Cristobal formation, New Mexico. (p. 322)

22—*Fusulinella* aff. *F. devexa* Thompson. Axial section, ×20. Three miles west of Pryor, Oklahoma (O-46). (p. 322)

23—*Fusulinella? primaeva* (Skinner). Axial section of a syntype, ×20. Base of Big Saline limestone, Texas. (p. 322)

24—*Fusulinella velmae* Thompson. Axial section of a syntype, ×20. Lower Hartville limestone, Wyoming. (p. 322)

LARGER FORAMINIFERA FROM THE UPPER EOCENE OF COSTA RICA*

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Professor W. A. Kelly of Michigan State College sent W. P. Woodring of the United States Geological Survey specimens of limestone from the vicinity of Turrialba, Costa Rica, for age determination. These samples, collected by Dr. Paul C. Morrison of the geography department of Michigan State College, came from the following stations:

65BA1, 65BA2, 65BA3, from a road cut just east of Azul, about 1.5 miles in a direct line east-northeast of Turrialba.

65CA1, Jesus María, about 2½ miles in a direct line northeast of Turrialba.

65DA1, from a railroad cut between Jesus María and Las Animas, about 2 miles in a direct line east-northeast of Turrialba.

Twenty-four thin sections were prepared

* Publication authorized by the Director, United States Geological Survey.

from the five samples by the laboratory of the United States Geological Survey.

Lohmann and Brinkmann (1931, p. 554) list eight species of larger Foraminifera from the vicinity of Turrialba. In order to record this upper Eocene fauna in terms of the recent study (Cole, 1952 [1953]) of the larger Foraminifera of the Gatuncillo formation of Panama, this note is published.

The species listed by Lohmann and Brinkmann with the names that are used at present follow:

Species Listed by Lohmann and Brinkmann	Names Used at Present
Lepidocyclina cf. *L. panamensis* Cushman	*L.* (*Pliolepidina*) *pustulosa tobleri* H. Douvillé
macdonaldi Cushman	*macdonaldi* Cushman
subraulini Cushman	(*Nephrolepidina*) *chaperi* Lemoine and R. Douvillé
cf. *L. perundosa* Cushman	*chaperi* Lemoine and R. Douvillé
Discocyclina cubensis Vaughan	*Asterocyclina minima* (Cushman)
antillea Vaughan	*mariannensis* (Cushman)
Operculina cf. *O. davidensis* Cushman	*Operculinoides ocalanus* (Cushman)
Nummulites parvula Vaughan	*Amphistegina* sp.

The following table gives the species present and their occurrence at the five stations:

Distribution of Upper Eocene Species Near Turrialba

	65BA1	65BA2	65BA3	65CA1	65DA1
Operculinoides ocalanus (Cushman)	×	×	×		×
Heterostegina ocalana Cushman	×	×			×
Lepidocyclina (*Pliolepidina*) *macdonaldi* Cushman	×	×	×		
putulosa H. Douvillé				×	
pustulosa tobleri H. Douvillé	×	×	×		×
(*Nephrolepidina*) *chaperi* Lemoine and R. Douvillé			×	×	×
Helicolepidina spiralis Tobler		×	×		
Asterocyclina georgiana (Cushman)	×	×	×		
mariannensis (Cushman)	×	×	×		
minima (Cushman)	×	×	×		×

The composite fauna contains nine species and one variety, all of which occur together in the Gatuncillo formation (Cole, 1952 [1953], p. 4) of Panama. Five of the species and one variety are found in the San Fernando (or Mount Moriah) formation (Vaughan and Cole, 1941, p. 27) of Trinidad. This fauna characterizes the "unnamed limestone near Turrialba" shown on the correlation chart in "Correlation of the Cenozoic formations of the Atlantic and Gulf Coastal Plain and the Caribbean region" prepared by Cooke, Gardner, and Woodring (1943). This "unnamed limestone" definitely correlates with the Gatuncillo formation (middle(?) and upper Eocene) of Panama (Woodring and Thompson, 1949, p. 227) and the San Fernando (or Mount Moriah) formation of Trinidad.

The thin sections on which this study is based are deposited in the United States National Museum.

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Woodring, W. P., and Thompson, T. F., 1949, Tertiary formations of Panama Canal Zone and adjoining parts of Panama: Bull. Amer. Assoc. Petrol. Geol., vol. 33, pp. 223–247, 2 figs.

TAXONOMIC COMMENT ON: "OSTRACODA FROM WELLS IN NORTH CAROLINA PART I: CENOZOIC OSTRACODA" BY F. M. SWAIN

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I have just read a recent paper by F. M. Swain (1951), in which he has either discussed or illustrated 114 species of Ostracoda, more than one-half tentatively. Swain's paper is very generalized stratigraphically, and little attempt is made to segregate such families, subfamilies, and genera and species as are in current use. Since all misidentifications in paleontology are perpetuated in print if not corrected, and since the report will be used by both stratigraphers and paleontologists, some of the more serious and obvious mistakes should be indicated:

1. "*Xestoleberis* cf. *X. longissima* Schmidt" (p. 18) and "*Xestoleberis* sp." (p. 18; text fig. 3d). Explanation to text figure 3d (p. 15) reads "*Xestoleberis* sp." Both of these species belong to *Cytheridеis* Jones and should therefore be changed to *Cytheridеis* cf. *C. longissima* (Schmidt) and *Cytheridеis?* sp. respectively.

2. "*Haplocytheridea?* cf. *H. subovata* (Ulrich and Bassler)" (p. 22). The name *Cytheridea subovata* Ulrich and Bassler (1904, p. 124) is the original name. It is not *Cythere subovata* Münster (1830, p. 63) which was later changed to *Cytheridea subovata* by Egger (1858, pp. 417, 418). Since *Cytheridea subovata* Ulrich and Bassler was a homonym of *Cytheridea subovata* (Münster) of Egger, a new name, *bassleri* was proposed by Stephenson (1943, p. 206) for Ulrich and Bassler's species. The correct name, therefore, is *Haplocytheridea bassleri* Stephenson.

The genera *Cytheridea, Haplocytheridea, Clithrocytheridea* could have been classified under *Cytherideinae* Sars, 1925.

3. "*Loxoconcha subrhomboidea* Edwards" (p. 25) is preoccupied by *Loxoconcha subrhomboidea* Brady (1880, p. 121, pl. 28, figs. 4a–d). Dr. Richard Edwards (personal communication, June, 1953) proposes *Loxoconcha purisubrhomboidea* Edwards, n. name for *Loxoconcha subrhomboidea* Edwards (1944, p. 527, pl. 88, figs. 28–32).

4. "*Trachyleberis? martini* (Ulrich and Bassler)" and "*Trachylebris* cf. *micula* (Ulrich and Bassler)" (p. 29). The original names are *Cythere martini* Ulrich and Bassler (1904, p. 116). The original description of *Cythere micula* was based on immature moults of *C. martini*. The species should read *Cythere martini* and *Cythere micula* should be included under its synonomy. This species should have been left under *Cythereis* Jones instead of transferring it to a spinose genus to which it does not belong.

One of the genera that is mistreated without any emendments is *Trachyleberis* Brady 1898 (Swain, pp. 28–36). Of the 20 species included in this genus, only one (*Cythereis smithvillensis*) could be classed under *Trachyleberis*. For a detailed discussion of the genus *Trachyleberis*, reference is made to Sylvester-Bradley (1948), Harding and Sylvester-Bradley (1953) and Puri (1953).

5. "*Trachyleberis exanthemata* (Ulrich and Bassler)" (p. 37) includes in its synonomy *Cythereis exanthemata marylandica* Howe and Huff (sic). Howe and Hough's variety is valid.

6. "*Trachyleberis vaughani* (Ulrich and Bassler)" (p. 37) and *T.? bassleri* (Ulrich) could have better been included under the genus *Cythereis* (*Cythereis*) Jones (Skogsburg 1928, pp. 38–56).

7. "*Trachyleberis? rugipunctata* (Ulrich and Bassler)" (p. 38). *Cythere rugipunctata* Ulrich and Bassler (1904, p. 118) is the original name. Coryell and Fields (1937, p. 8) described a new genus *Favella* from the Gatun Miocene of Panama; genotype by original designation is *Favella puella* Coryell and Fields (1937, pp. 8, 10). As previously pointed out (Edwards 1944, pp. 523, 524) this species was described on immature moults of *Cythereis rugipunctata gatunensis* Coryell and Fields (1937, p. 10). There is hardly any doubt that *Cythereis rugipunctata gatunensis* is a synonym of *Favella puella*. The genus *Favella* Coryell and Fields

is preoccupied by *Favella* Jörgensen (1925, p. 25). Dr. H. N. Coryell (personal communication, April, 1953) has suggested *Puriana* Coryell and Fields n. name for *Favella* Coryell and Fields. "*Trachyleberis? rugipunctata* (Ulrich and Bassler)" should therefore be classed under *Puriana* Coryell and Fields. It is rather unfortunate that Swain recognizes "*Favella*" *mesacostalis* Edwards (p. 41) but transfers a more typical species (*rugipunctata*) to *Trachyleberis?*

8. "*Buntonia* cf. *B. lacunosa* (Jones)" (p. 39). The original name is *Cythere lacunosa* Jones (1857, p. 31, pl. 3, figs. 5a, b). Jones (1870, p. 156) renamed this species *Cythere sublacunosa* Jones, n. name, because of *Cypridina lacunosa* Reuss (1850, p. 70, pl. 9, figs. 27a, b) which Jones considered to be a *Cythere*. Jones and Sherborn (1889, p. 27) used *Cythere sublacunosa*.

9. "*Leguminocythereis* Howe" (p. 43). This genus (Howe, in Howe and Law 1936, pp. 61–62) is meant to include *Cythereis*-like forms that usually have a reticulate ornamentation, which in the dorsal half "tends to radiate from the center of the dorsal margin and which in the ventral half, tend to parallel the ventral margin" (Howe, in Howe and Law 1936, p. 61). *Leguminocythereis clarkana* (Ulrich and Bassler) (p. 43) is echinate, has a different muscle scar pattern and should not be included with *Leguminocythereis*. *Cythere exax* Ulrich and Bassler, *Trachyleberis rosetta* Swain, *Cythereis garretti* Howe and McGuirt, *Cythereis okeechobeensis* and *C. clarkana* are related forms and I will soon be erecting a new genus for their reception.

10. "*Cytheretta* cf. *plebeia* (Ulrich and Bassler)" (p. 45), was originally described as *Cythere plebeia* Ulrich and Bassler (1904, p. 102) and is a junior homonym of *Bairdia plebeia*, 1854 equals *Cythere* (*Bairdia*) *plebeia* Kirby, 1858, p. 324. Puri (1952, p. 204) therefore, proposed a new name *C. ulrichi* for Ulrich and Bassler's species. The name *C. porcella* Ulrich and Bassler should have been used to replace *Cythere plebeia* Ulrich and Bassler rather than the new name *C. ulrichi* Puri, since Puri (1952, p. 199) recognized that *C. porcella* represents young moults of *C. plebeia* of Ulrich and Bassler. "*Cytheretta* cf. *C. plebeia*" and *Cytheretta?* sp. aff. *C. plebeia*" (p. 45) should therefore be included with *C. porcella* (Ulrich and Bassler).

11. "*Cytheretta karlana* Howe and Pyeatt (p. 46) and *C. reticulata* Edwards" are not conspecific, but distinct species. *C. karlana* is restricted to Chipola, Oak Grove and Shoal River parvafacies of the Chipola magnafacies, and does not occur in Choctawhatchee equivalents. Swain's form is *C. reticulata* Edwards.

12. "*Basslerites* cf. *B. miocenicus* (Howe)" (p. 47), is not *miocenicus*. *B. miocenicus* is a much smaller form with deep, oval, oblique socket on the posterior cardinal angle.

13. "*Cytherura reticulata* Edwards" (p. 50). It is not *Cytherura reticulata* Lienenklaus (1894, p. 242, pl. 16, figs. 11a, b) from the German Oligocene, nor *Cytherura reticulata* Müller, (1894, p. 298, pl. 17, figs. 12, 13; pl. 19, fig. 17) from the Recent of Naples. Dr. Richard Edwards (op. cit.) supplies *Cytherura purireticulata* Edwards, n. name, for *Cytherura reticulata* Edwards (1944, p. 526, pl. 88, figs. 13–16).

14. "*Paracytheridea nodosa* (Ulrich and Bassler)" (p. 51). The original name is *Cytheropteron nodosum* Ulrich and Bassler. It is not *Cytheropteron nodosum* Brady (in Norman 1867, p. 198, not described), nor *Cytheropteron nodosum* Brady (1868, p. 448, pl. 34, figs. 31–34). Van den Bold (1946, p. 86) noted that it needed a new name. *Paracytheridea vandenboldi* Puri, n. name, is here proposed for Ulrich and Bassler's form.

15. "*Paracytheridea? wetherelli* (Jones)" (p. 51). The original name is *Cythere wetherelli* Jones (1854, p. 161, pl. 3, fig. 9). Jones (1870, pp. 156, 158) placed it in *Loxoconcha*.

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NOMENCLATURAL NOTES

THE NOMENCLATURE OF THE OSTRACODE GENUS *CYTHERIDEIS*

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ABSTRACT—*Cytherideis unicornis* Jones, 1856 is designated as the type species of the genus *Cytherideis*, which then becomes a synonym of *Cypridea* Bosquet, 1852. The correct name for the containing subfamily becomes Cyprideinae Martin, 1940. *Sahnia* Puri, 1952 is regarded as a synonym of *Neocytherideis* Puri, 1952.

INTRODUCTION

The nomenclatorial interpretation of the ostracode genus *Cytherideis* has always been confused. It is regrettable that the recent paper by Puri (1952) has, by misidentification and a disregard of the Rules of Nomenclature, added much to the confusion. As mentioned by Puri, we had filed with the International Commission on Zoological Nomenclature an application to have the selection of type species legalized. Our intention was to prevent further confusion. It now appears to us, however, that such an application would but stimulate further controversy. The rigid application of the Rules would, as we show below, lead to the suppression of the name *Cytherideis* as a synonym of *Cypridea*. This we believe to be preferable to the otherwise anarchic situation in which some would base the genus on *C. subulata* (chosen by Brady and Norman in 1889), others on *C. trigonalis* (chosen by van den Bold in 1946), and still others on *C. botellina* (chosen by Puri in 1952).

We have accordingly withdrawn our application from the International Commission. As Puri's invalid choice of type species has already been followed by Cheetham (1952) and Munsey (1953), we believe it desirable to set out the nomenclatorial position without delay. We hope to describe in another place the type species of the genera we show to be nomenclatorially valid.

The name *Cytherideis* was first published by Jones (1856) for two species of Ostracoda from the Tertiary of the Isle of Wight which were thought at the time to be new. One (*C. unicornis*) was later (Jones and Sherborn, 1887) shown to be a synonym of *Cypridea spinigera* (Sowerby), and the other (*C. unisulcata*) thought to be an immature specimen of either *Cypridea* or *Metacypris* (Jones and Sherborn, 1889). At one time the publication of a new generic name without *generic* diagnosis would have been considered invalid (Hemming, 1944), and this was the situation when the nomenclatorial position was discussed by one of us previously (Sylvester-Bradley, 1947). Since then, however, Opinion 1 has been rescinded by the International Commission (Hemming, 1950, pp. 78–80). The name *Cytherideis* therefore dates from 1856, and the syntype species are *C. unicornis* Jones, 1856 and *C. unisulcata* Jones, 1856. We now formally designate *Cytherideis unicornis* Jones, 1856 as type species, and this we believe to be the first valid designation made, all earlier attempts naming species which were not included in the original citation. The species we regard to be correctly assigned to *Cypridea* Bosquet, 1852. The name *Cytherideis* must in consequence be abandoned as a synonym of *Cypridea*.

Van den Bold (1946) chose *Cythere trigonalis* Jones, 1850 as type species. This was the first species described by Jones (1857) under the genus *Cytherideis*, but was later transferred to the genus *Potamocypris* by Jones and Sherborn (1887). Nevertheless, the designation would, if *Cytherideis* had dated from 1857 instead of from 1856,

have had priority over the invalid designations considered in the next paragraph. This would not have been a happy choice, however, for *Cytherideis* has priority over *Potamocypris* Brady, 1870, and even if it had been valid there might, in that case, have been good cause to apply to the International Commission for suppression of the designation.

The species included within the genus *Cytherideis* by Jones (1857) included, besides the above-mentioned *C. unisulcata*, *C. unicornis* and *C. trigonalis*, six other species, one of which was identified with *Cythere flavida* O. F. Müller, 1785. This species was subsequently shown to have been misidentified. Brady (1867) created a new name (*Cytherideis subulata*) for some of the specimens described by Jones, and Jones (1870) himself created another new name (*Cytherideis botellina*) for others of these misidentified specimens. The true *Cythere flavida* of O. F. Müller was regarded by G. W. Müller (1912) as both generically and specifically indeterminable; Brady (1868) and Brady and Norman (1889) thought it might possibly be the species known as *Paradoxostoma variabile* (Baird, 1835). None of these three species are available under the Rules for designation as lectotype-species of *Cytherideis*, not being among the two names originally cited. Brady and Norman's (1889) choice of *C. subulata* and Puri's (1952) choice of *C. botellina* are equally invalid. It may be mentioned that the type specimens of *C. botellina* are preserved in the British Museum. They show that there is some confusion in the identity of this species, which needs revision. Two species, which are not congeneric, are in fact represented by the specimens.

Puri (1952) created a new subfamily "Cytherideisinae" based on *Cytherideis*. The name is incorrectly formed. The Rules (Article 4) state that family and subfamily names should be based on the classical stem of the name of the type genus (see also Hemming, 1950, p. 246; and Hemming, 1952). The stem of *Cytherideis* is *Cytherideid-*, and the subfamily name must therefore be emended to Cytherideidinae. When, however, the genus *Cytherideis* is regarded as synonymous with *Cypridea*, the subfamily based on it becomes a synonym of Cyprideinae Martin, 1940. As such, the subfamily name can also be abandoned.

Should it be considered desirable to recognize the same taxonomic unit as Puri intended when he introduced this unfortunate name, it could be based on any of the valid generic names it contained. The present authors have no wish, in this paper, to propose such a name.

Ruggieri (1952) created a new genus *Hemicytherideis* with *Cytheridea elongata* Brady, 1868 as type species. This genus is valid, and was regarded by Puri as synonymous with his concept of *Cytherideis*. Species described as *Cytherideis* by Puri (1952), Cheetham (1952) and Munsey (1953) should therefore be transferred to *Hemicytherideis*.

Puri (1952) created a new genus *Sahnia* with type species *Cytherideis subulata* Brady, 1867. The specimens described as *C. subulata* are not, however, correctly identified. It is true (as Puri quotes on the authority of one of us) that the type specimens of *C. subulata* cannot be found. The species was founded by Brady on the specimens described by Baird (1850) under the name "*Cythere flavida*" from Cockburnspath, Berwickshire, Scotland, and from Torquay, Devon, England. These are therefore the syntype localities. Although the type specimens are lost, and although existing published descriptions are inadequate and misleading, the species is well characterized in the collections of the British Museum, and good descriptions exist of closely allied species (e.g., Müller, 1894, pp. 380–382, Pl. 31, figs. 40–51; Ruggieri, 1952, fig. 4). Puri has therefore nothing in his favor when he refers to his misidentified specimens from Swanage (misspelt "Swange" by Puri in both the places he quotes it), Dorset, England as "neotypes." Swanage is not one of the type localities, Puri is unfamiliar with the existing museum material, and the category "neotype" has not yet been recognized by the International Commission. The genus *Sahnia* Puri must, by the Rules of Nomenclature, be based on the true *Cytherideis subulata*.

Puri (1952) created another new genus *Neocytherideis*, based on a species which was given the new name *N. elongatus* Puri. This

also is a Recent species from the Swanage shore. It would appear to be a synonym of *Cytherideis subulata* var. *fasciata* Brady and Robertson, 1874. It is closely allied to *C. subulata* sensu stricto and in our opinion certainly congeneric with it. Thus *Sahnia* and *Neocytherideis* are synonyms of each other.

Our conclusions can be summarized in the scheme below:

Suborder PODOCOPA
Superfamily CYPRACEA
Family CYPRIDEIDAE Martin
Subfamily CYPRIDEINAE Martin, 1940
Cytherideidinae Puri, 1952 (Type-genus *Cytherideis*)
Type genus *Cypridea*

Genus *Cypridea* Bosquet, 1852
Cytherideis Jones, 1856 (Type sp. *C. unicornis* Jones)
Type sp.: *Cypris granulosa* J. de C. Sowerby

Superfamily CYTHERACEA
Family CYTHERIDEIDAE
Type genus *Cytheridea*
Genus *Hemicytherideis* Ruggieri
Cytherideis of some authors, incl. Puri, 1952
Type sp. *Cytheridea elongata* Brady, 1868
Genus *Neocytherideis* Puri, 1952
Sahnia Puri, 1952 (Type sp. *Cytherideis subulata* Brady)
Type sp. *N. elongatus* Puri, 1952 (= *Cytherideis subulata* var. *fasciata* Brady & Robertson, 1874)

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NEW NAME FOR *NIPPONASTER* DURHAM, 1952[1]

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It has kindly been called to my attention by both Hans E. Thalmann of Palo Alto, California, and Syózó Nisiyama of Matsue, Japan, that the generic name *Nipponaster* Durham (1952) which I proposed for a new genus of scutelloid echinoids of Japan is a homonym of *Niponaster* Lambert (1920, p. 26) with type species *N. hokkaidensis* Lambert (a spatangoid echinoid). Accordingly I hereby propose the generic name *Pseudastrodapsis* as a substitute for *Nipponaster* Durham (1952), non *Niponaster* Lambert (1920), with the type species as before, *Astrodapsis nipponicus* Nisiyama.

[1] A contribution from the Museum of Paleontology of the University of California.

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FAMILY ENDINGS

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It is generally agreed that the International Code and the Opinions of the International Commission on Zoological Nomenclature (reprinted in Schenk and McMasters) have been of inestimable value in stabilizing scientific names. Nevertheless, individual workers at times find themselves opposed to particular Articles or Opinions. Sometimes this opposition is so strong that the individual is constrained to solve his particular problem at variance with the rules. Unfortunately, the solution thus attained is usually of short duration, for the "error" is soon "corrected" and another variant spelling is formed. Examples of such emendations are found in Opinions 26, 27, 29, 36, 41, 60, 61 and 63. These are based on Article 19 of the Code, which provides for emendation because of error of transcription, a *lapsus calami*, or a typographical error.

Stability of nomenclature is best achieved by following the accepted rules, and subjugating personal objections. The objections can then be taken up with the Commission, and such changes as prove desirable can be made. The philosophy here advocated is: follow the rules; if you don't like them, change them!

C. C. Branson has recently emphasized the great importance of authors giving derivations for their new names. This is necessary so that others may check the formation of the names and either substantiate or emend the original. Only thus can the correct form be established in the literature. Writers who have followed variant spellings through manuscript, typescript and galley proof to final publication know how annoying these variations can be. As a co-worker with C. L. Camp on the bibliographies of fossil vertebrates, the senior author heartily endorses Branson's recommendation. Errors in formation and subsequent emendations of a specific name can be annoying, but only the specific name is affected by such errors. On the other hand, the correction of a generic name will be likely to modify not only the name itself, but also the specific name (ending), and the family name, if a type genus. Correct formation of a generic name is therefore triply important.

However, it might be pointed out for legalistic minds, and for those who do not

want their names corrected, that under Opinion 34 the Commission refused to change the spelling of *Aeshna* because evidence of derivation was not contained in the original publication. Therefore an author who fails to give derivation cannot be corrected, and nomenclatorial stability results not from proposing a correct name, but from proposing one that cannot be changed! So, if an author seriously objects to having his name emended, he can purposefully omit the derivation. This renders his name immutable; but it also hides the real purpose of the name if that purpose is to emphasize a characteristic or a locality, or to honor a person.

An entirely different kind of nomenclatorial instability is encountered in the formation of family names. Article 4 of the International Code clearly states, "The name of a family is formed by adding *idae*, the name of a subfamily *inae*, to the stem of its type genus." With such unequivocal instructions we might expect a serene uniformity in the formation and use of family names. However, there are two parts to these instructions, hence two points of departure that can, and often do, lead to varying interpretations. One requires the author who proposes a family name to select the type genus, usually designated by a Greek word; the other requires him to determine the stem of this word.

An example, taken from the literature, of variation brought about by failure to determine correctly the stem of a Greek word, can be seen in the following forms: Zatrachydidae, Zatrachydae, Zatrachidae, Zatrachysidae, Zatrachyidae, and Zatracheidae. These variant spellings of a single family name are all based on *Zatrachys* Cope, 1878, hence do not arise from differences in selecting the type genus. They clearly result from incorrect determination of the stem of the word, and this is indeed the reason for many similar variations embedded in the literature.

In this example, Cope gave no derivation of his name *Zatrachys*, but it seems to have been correctly formed from the Greek prefix of emphasis *ζα-*, and the word *τραχύς*, meaning rough to the touch. If this be so, the problem is simply to find the stem of *trachys* and add to it the family ending, *-idae*.

The stem of a Greek or Latin word can usually be found by dropping the case ending from the genitive singular, the form of which is given in most Greek and Latin dictionaries. Thus from Latin *equus, equi*, we drop the terminal *-i* of the genitive *equi* and get the stem *equ-*. To this we add *-idae* to form Equidae.

Returning to our example, the family based upon the genus *Zatrachys*, we find the rather unusual formation of a name from an adjective. Its masculine, feminine and neuter forms in the nominative case are *τραχύς, τραχεῖα, τραχύ*; which become in the genitive *τραχέος, τραχείας, τραχέος*. From the genitive masculine *τραχέ-ος* we drop the ending *-ος* and have the stem *τραχε-*, which in transliteration is *trache-*. To this we add the ending *-idae* and form Tracheidae, hence Zatracheidae; and none of the other five combinations noted above is permissible under Article 4.

In indexing the bibliographies of fossil vertebrates, a number of such inconsistencies have been found to recur in the literature. Most of these are based upon a few words that seem to cause more than their share of trouble. These are listed here, with their meanings, in their nominative and genitive forms, showing the correct formation of the family names from the properly determined stems, as a guide to future workers. Transliteration of Greek words is in accord with Appendix F to the International Rules, although the authors would like to observe at this point that the table given by way of example (in Schenk and McMasters, p. 45) is inadequate and confusing. They hope however to propose substantial improvements in this table on some other occasion.

The list below includes a certain number of Latin, as well as a larger number of Greek words, and in both instances the genitive forms have been hyphenated for clarity and convenience.

The above list cannot be used indiscriminately to construct family names from all words with similar endings. Each word must be individually checked, by looking up the etymology or derivation of the

Nominative	Meaning	Genitive	Stem	Family Name
ἀσπίς	shield	ἀσπίδ-ος	aspid-	Aspididae
βοῦς	cow	βο-ός	bo-	Boidae
bos	cow	bov-is	bov-	Bovidae
brachium	arm	brachi-i	brachi-	Brachiidae
βραχίων	arm	βραχίον-ος	brachion-	Brachionidae
κεφαλή	head	κεφαλ-ῆς	cephal-	Cephalidae
χέλυς	turtle	χέλυ-ος	chely-	Chelyidae
κολοφών	summit	κολοφῶν-ος	colophon-	Colophonidae
δέρμα	skin	δέρματ-ος	dermat-	Dermatidae
ἐμύς	water tortoise	ἐμύδ-ος	emyd-	Emydidae
γνάθος	jaw	γνάθ-ου	gnath-	Gnathidae
ἕρπετον	crawler	ἑρπέτ-ου	herpet-	Herpetidae
ἰχθύς	fish	ἰχθύ-ος	ichthy-	Ichthyidae
leo	lion	leon-is	leon-	Leonidae
λέων	lion	λέοντ-ος	leont-	Leontidae
λεπίς	scale	λεπίδ-ος	lepid-	Lepididae
lepus	hare	lepor-is	lepor-	Leporidae
mus	mouse	mur-is	mur-	Muridae
μῦς	mouse	μυ-ός	my-	Myidae
ὀδούς	tooth	ὀδόντ-ος	odont-	Odontidae
ὤψ	face	ὠπ-ός	op-	Opidae
ὄψις	aspect	ὄψε-ως	opse-	Opseidae
ὄρνις	bird	ὄρνιθ-ος	ornith-	Ornithidae
pes	foot	ped-is	ped-	Pedidae
πούς	foot	ποδ-ός	pod-	Podidae
ῥάχις	spine	ῥάχε-ως	rhache-	Rhacheidae
σκέλος	leg	σκέλε-ος	scele-	Sceleidae
σῶμα	body	σώματ-ος	somat-	Somatidae
στέγος	house	στέγε-ος	stege-	Stegeidae
στέγη	roof	στέγ-ης	steg-	Stegidae
στόμα	mouth	στόματ-ος	stomat-	Stomatidae
θυρίς	opening	θυρίδ-ος	thyrid-	Thyrididae
τραχύς	rough	τραχέ-ος	trache-	Tracheidae
τρίτων	triton	τρίτων-ος	triton-	Tritonidae

generic name. Only thus will one know, in the first place, whether the stem is Greek, Latin, or barbaric. If Greek or Latin, one can then usually form the family name correctly, as shown above. However, if the original author did not give the derivation, or if the name is of barbaric origin and there is no proper stem, there is in such a case no uniform solution except through common sense and the acceptance and retention of the first name proposed.

Standard authorities on the Greek language are cited in the following references, The two writers of this article, however, make bold to suggest that if their collaboration has seemed worthwhile to their readers, it serve as an example of procedure, and encourage the natural historian to consult more frequently with the classicist in problems of scientific terminology.

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HOWELLISAURA, NEW NAME FOR *HOWELLITES* BOCK

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Dr. H. B. Whittington was kind enough to advise the writer that the name *Howellites* proposed for a genus of estherids (Jour. Paleontology, vol. 27, p. 70; type species *H. princetonensis* Bock, n. sp.) has been used previously by Bancroft for a subgenus of brachiopods (Jour. Paleontology, vol. 19, p. 203). As replacement the writer proposes the new generic name *Howellisaura*, having as type species *Howellites princetonensis* Bock (ibid., vol. 27, p. 71).

NEW NAME FOR *CYATHOPHYLLUM QUADRIGEMINUM ARCTICA* LOEWE

ERWIN C. STUMM
University of Michigan

Cyathophyllum quadrigeminum mut. nov. *arctica* Loewe, 1919, Rept. Second Norwegian Arctic Exped. in the "Fram," no. 30, p. 9, pl. 2, figs. 3a–c is a homonym of *Cyathophyllum arcticum* Meek, 1868, Trans. Chicago Acad. Sci., vol. 1, p. 79, pl. 1, figs. 8–8a. In order to correct this before appearance of the forthcoming installment of the Catalogue of North American Devonian Fossils, *Cyathophyllum quadrigeminum* mut. nov. *arctica* Loewe is here renamed *Hexagonaria loewei.*

NEW NAME FOR *PRISMATOPHYLLUM PARVULUM* SMITH 1945

STANLEY SMITH
The University, Bristol, England

Dr. Erwin C. Stumm has very kindly drawn my attention to the fact that *Prismatophyllum parvulum* Smith (1945, p. 50, pl. 17, figs. 6a, b, 7a, b. Upper Devonian, Trout River, NW Canada) is preoccupied by *P. parvulum* Stainbrook (1940, p. 279, pl. 35, fig. 6; pl. 38, figs. 5–7. Upper Devonian, Cedar Valley, Iowa). I therefore rename the Canadian coral *Hexagonaria caurus* (Caurus; NW wind).

Prismatophyllum Simpson (1900, p. 218) is a synonym of *Hexagonaria* Gürich (1896, p. 171) since *Prismatophyllum prisma* Lang and Smith (1935, p. 558) = *Cyathophyllum rugosum* (Hall) Edwards and Haime (1851, p. 378, pl. 12, figs. 1, 1a, 1b), partim, holotype of *Prismatophyllum*, is congeneric with *Cyathophyllum hexagonum* Goldfuss partim, (1826, p. 61, pl. 19, figs. 5e, f; pl. 20, figs. 1a, b, [but excluding pl. 19, figs. 5a–d]) the lectotype of which is the specimen figured by Goldfuss (1826, pl. 20, figs. 1a, b; see Lang and Smith, 1935, p. 550). For detailed description of *Hexagonaria prisma* (Lang and Smith) and figures of holotype see Smith (1945, p. 45, pl. 14, figs. 1a–f).

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SOCIETY RECORDS AND ACTIVITIES

NOMINATIONS FOR MEMBERSHIP

In accordance with Article 3, Chapter 1, of the By-Laws of the Paleontological Society, the Secretary submits the following nominations for membership in the Society. The list has been approved by the Council of the Society.

ADDICOTT, WARREN OLIVER, Dept. Paleontology, Univ. Calif., Berkeley, Calif.: J. Wyatt Durham, William K. Emerson, Joseph H. Peck, Jr.

AXELROD, DANIEL I., Dept. Geol., Univ. Calif., Los Angeles 24, Calif.: W. P. Popenoe, Alexander Stoyanow.

BALSEIRO, LINA MERCEDES, Hamilton Hall, Miami Univ., Oxford, Ohio: W. H. Shideler, Karl E. Limper.

BLACK, DONALD MILTON, Box 144, Grand Canyon, Arizona: W. P. Popenoe, Alexander Stoyanow.

DULANTO, ALEJANDRO EURIBE, Empresa Petrolera Fiscal, Tumbes, Peru, South America: Walter Youngquist, Alfred G. Fischer.

FELIX, CLARENCE ERNEST, 1565 Kappa #2, Salt Lake City, Utah: Walter Sadlick, J. Stewart Williams.

FRY, WAYNE LYLE, Dept. Botany, Cornell Univ., Ithaca, New York: J. W. Wells, W. Storrs Cole.

HANSMAN, ROBERT H., Geol. Dept., State Univ. Iowa, Iowa City, Iowa: A. K. Miller, M. L. Thompson.

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WINDER, CHARLES GORDON, Dept. Geol., Univ. Western Ont., London, Ontario: W. Storrs Cole, J. W. Wells.